3D mapping of the Earth's trapped radiation particles using μASC: from the inner zone to the magnetosphere

As a pioneer of the fully autonomous star trackers, the micro Advanced Stellar Compass (DTU Space) has been operating successfully on numerous satellite missions ranging from Low Earth Orbiters (e.g. ESA’s Swarm) to Deep Space missions (e.g. NASA’s Juno), accurately providing absolute attitude reference. Besides its primary function of attitude determination, the μASC is also capable of detecting and monitoring the population of the Earth’s high energy particles. The particles with energies high enough (>20MeV) to pass the heavy shielded optics, will leave a temporary trace on the CCD sensor. The signature of these high energy particles is eliminated in flight by the instrument software ensuring full performance even during the most intense CMEs. Mapping the rate of the penetrating particles on the CCD sensor enables the monitoring of the high energy particle flux. We present compilation of detected particle flux, its global maps and radial variation from 400 to 10000 km altitude. We further present a view of the dynamic part of the flux, from injection sources such as CMEs, which gives a detailed profiling of the direction, injection time scales and relaxation times.

Accelerating changes in ice mass within Greenland, and the ice sheet's sensitivity to atmospheric forcing

From early 2003 to mid-2013, the total mass of ice in Greenland declined at a progressively increasing rate. In mid-2013, an abrupt reversal occurred, and very little net ice loss occurred in the next 12-18 months. Gravity Recovery and Climate Experiment (GRACE) and global positioning system (GPS) observations reveal that the spatial patterns of the sustained acceleration and the abrupt deceleration in mass loss are similar. The strongest accelerations tracked the phase of the North Atlantic Oscillation (NAO). The negative phase of the NAO enhances summertime warming and insolation while reducing snowfall, especially in west Greenland, driving surface mass balance (SMB) more negative, as illustrated using the regional climate model MAR. The spatial pattern of accelerating mass changes reflects the geography of NAO-driven shifts in atmospheric forcing and the ice sheet's sensitivity to that forcing. We infer that southwest Greenland will become a major future contributor to sea level rise.
Active Galactic Nuclei in Dusty Starbursts at z=2: Feedback Still to Kick in

We investigate a sample of 152 dusty sources at 1.5 < z < 2.5 to understand the connection of enhanced star formation rate (SFR) and black hole accretion rate. The sources are Herschel-selected, having stellar masses $M_\star > 10^{10} M_\odot$ and SFR ($\sim$100–1000 $M_\odot$ yr$^{-1}$) elevated (>4x) above the star-forming "main sequence," classifying them as starbursts (SBs). Through a multiwavelength fitting approach (including a dusty torus component), we divided the sample into active SBs (dominated by an active galactic nucleus (AGN) emission, SBs-AGN, ~23% of the sample) and purely star-forming SBs (SBs-SFR). We visually inspected their Hubble Space Telescope/ultraviolet (UV) rest frame maps: SBs-SFR are generally irregular and composite systems; ~50% of SBs-AGN are instead dominated by regular compact morphologies. We then found archival Atacama Large Millimeter/submillimeter Array continuum counterparts for 33 galaxies (12 SBs-AGN and 21 SBs-SFR). For these sources we computed dust masses, and, with standard assumptions, we also guessed total molecular gas masses. SBs turn into gas-rich systems ($f_{\text{gas}} = M_{\text{gas}}/(M_{\text{gas}} + M_\star) \sim 20\%–70\%$), and the gas fractions of the two SB classes are very similar ($f_{\text{gas}} = 43\% \pm 4\%$ and $f_{\text{gas}} = 42\% \pm 2\%$). Our results show that SBs are consistent with a mixture of: (1) highly star-forming merging systems (dominating the SBs-SFR) and (2) primordial galaxies, rapidly growing their $M_\star$ together with their black hole (mainly the more compact SBs-AGN). Feedback effects have not yet reduced their $f_{\text{gas}}$. Indeed, SBs at $z = 2$, with relatively low bolometric AGN luminosities in the range $10^{44} < L_{\text{bol}} (\text{AGN}) < 10^{46} \text{ erg s}^{-1}$ (compared to bright optical and X-ray quasars), are still relatively far from the epoch when the AGN feedback will quench the SFR in the host and will substantially depress the gas fractions.

A giant impact as the likely origin of different twins in the Kepler-107 exoplanet system

Measures of exoplanet bulk densities indicate that small exoplanets with radius less than 3 Earth radii ($R_\oplus$) range from low-density sub-Neptunes containing volatile elements$^1$ to higher-density rocky planets with Earth-like$^2$ or iron-rich$^3$ (Mercury-like) compositions. Such astonishing diversity in observed small exoplanet compositions may be the product of different initial conditions of the planet-formation process or different evolutionary paths that altered the planetary properties after formation$^4$. Planet evolution may be especially affected by either photoevaporative mass loss induced by high stellar X-ray and extreme ultraviolet (XUV) flux$^5$ or giant impacts$^6$. Although there is some evidence for the former$^7$, there are no unambiguous findings so far about the occurrence of giant impacts in an exoplanet system. Here, we characterize the two innermost planets of the compact and near-resonant system Kepler-107 (ref.9). We show that they have nearly identical radii (about 1.5–1.6$R_\oplus$), but the outer planet Kepler-107 c is more than twice as dense (about 12.6 g
cm$^{-3}$) as the innermost Kepler-107 b (about 5.3 g cm$^{-3}$). In consequence, Kepler-107 c must have a larger iron core fraction than Kepler-107 b. This imbalance cannot be explained by the stellar XUV irradiation, which would conversely make the more-irradiated and less-massive planet Kepler-107 b denser than Kepler-107 c. Instead, the dissimilar densities are consistent with a giant impact event on Kepler-107 c that would have stripped off part of its silicate mantle. This hypothesis is supported by theoretical predictions from collisional mantle stripping$^{10}$, which match the mass and radius of Kepler-107 c.

A Hot Saturn Orbiting an Oscillating Late Subgiant Discovered by TESS

We present the discovery of HD 221416 b, the first transiting planet identified by the Transiting Exoplanet Survey Satellite (TESS) for which asteroseismology of the host star is possible. HD 221416 b (HIP 116158, TOI-197) is a bright (V = 8.2 mag), spectroscopically classified subgiant that oscillates with an average frequency of about 430 μHz and displays a clear signature of mixed modes. The oscillation amplitude confirms that the redder TESS bandpass compared to Kepler has a small effect on the oscillations, supporting the expected yield of thousands of solar-like oscillators with TESS 2 minute cadence observations. Asteroseismic modeling yields a robust determination of the host star radius (R$^*$ = 2.943 ± 0.064 R$\odot$), mass (M$^*$ = 1.212 ± 0.074 M$\odot$), and age (4.9 ± 1.1 Gyr), and demonstrates that it has just started ascending the red-giant branch. Combining asteroseismology with transit modeling and radial-velocity observations, we show that the planet is a "hot Saturn" (R$^p$ = 9.17 ± 0.33 R$\oplus$) with an orbital period of ~14.3 days, irradiance of F = 343 ± 24 F$\oplus$, and moderate mass (M$^p$ = 60.5 ± 5.7 M$\oplus$) and density (ρ$^p$ = 0.431 ± 0.062 g cm$^{-3}$). The properties of HD 221416 b show that the host-star metallicity–planet mass correlation found in sub-Saturns (4–8 R$\oplus$) does not extend to larger radii, indicating that planets in the transition between sub-Saturns and Jupiters follow a relatively narrow range of densities. With a density measured to ~15%, HD 221416 b is one of the best characterized Saturn-size planets to date, augmenting the small number of known transiting planets around evolved stars and demonstrating the power of TESS to characterize exoplanets and their host stars using asteroseismology.
Aircraft and Ship Velocity Determination in Sentinel-2 Multispectral Images

The Sentinel-2 satellites in the Copernicus program provide high resolution multispectral images, which are recorded with temporal offsets up to 2.6 s. Moving aircrafts and ships are therefore observed at different positions due to the multispectral band offsets, from which velocities can be determined. We describe an algorithm for detecting aircrafts and ships, and determining their speed, heading, position, length, etc. Aircraft velocities are also affected by the parallax effect and jet streams, and we show how the altitude and the jet stream speed can be determined from the geometry of the aircraft and/or contrail heading. Ship speeds are more difficult to determine as wakes affect the average ship positions differently in the various multispectral bands, and more advanced corrections methods are shown to improve the velocity determination.

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ALMA Reveals Potential Evidence for Spiral Arms, Bars, and Rings in High-redshift Submillimeter Galaxies

We present subkiloparsec-scale mapping of the 870 μm ALMA continuum emission in six luminous (LIR ∼ 5 × 10^{12} L⊙) submillimeter galaxies (SMGs) from the ALESS survey of the Extended Chandra Deep Field South. Our high-fidelity 0."07-resolution imaging (∼500 pc) reveals robust evidence for structures with deconvolved sizes of ≤0.5–1 kpc embedded within (dominant) exponential dust disks. The large-scale morphologies of the structures within some of the galaxies show clear curvature and/or clump-like structures bracketing elongated nuclear emission, suggestive of bars, star-forming rings, and spiral arms. In this interpretation, the ratio of the "ring" and "bar" radii (1.9 ± 0.3) agrees with that measured for such features in local galaxies. These potential spiral/ring/bar structures would be consistent with the idea of tidal disturbances, with their detailed properties implying flat inner rotation curves and Toomre-unstable disks (Q < 1). The inferred one-dimensional velocity dispersions (σr ≲ 70–160 km s⁻¹) are marginally consistent with the limits implied if the sizes of the largest structures are comparable to the Jeans length. We create maps of the star formation rate density (ΣSFR) on ∼500 pc scales and show that the SMGs are able to sustain a given (galaxy-averaged) ΣSFR over much larger physical scales than local (ultra)luminous infrared galaxies. However, on 500 pc scales, they do not exceed the Eddington limit set by radiation pressure on dust. If confirmed by kinematics, the potential presence of nonaxisymmetric structures would provide a means for net angular momentum loss and efficient star formation, helping to explain the very high star formation rates measured in SMGs.

Analysis of the GRAV-D airborne gravity data for geoid modelling

In this study, airborne gravity data from the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project are compared with terrestrial gravity data in three survey blocks that cross the Canada-US border. One block (AN04) overlaps an area containing Alaska (USA) and the Yukon Territory (Canada) over a rough terrain while the other two blocks (EN05 and EN08) are within the Great Lakes-St-Lawrence River region with flat and moderate terrains. GRAV-D has an average flight altitude of about 6 km in the three blocks, in which each survey/cross line spans 240–700 km. The high flight altitude of GRAV-D puts forth a challenge for the comparisons. We have developed procedures to interpolate...
and continue the airborne and terrestrial gravity data to a mean flight height for each block. The remove-compute-restore Poisson method is used in the upward continuation of the terrestrial gravity data by removing and restoring the satellite-only geopotential model GOCO05S. The comparison between the datasets is done using Helmert gravity disturbances in order to satisfy the harmonic condition of the upward continuation. The comparisons show that differences between GRAY-D and terrestrial gravity data are 3.6 mGal for AN04, 1.8 mGal for EN05 and 2.3 mGal for EN08 in terms of Root Mean Square (RMS) at the mean flight height. The results can be improved for two blocks when applying a cross-over adjustment. The differences become 1.0 and 1.4 for EN05 and EN08, respectively.

An attempt to observe vertical land motion along the norwegian coast by CryoSat-2 and tide gauges

Present-day climate-change-related ice-melting induces elastic glacial isostatic adjustment (GIA) effects, while paleo-GIA effects describe the ongoing viscous response to the melting of late-Pleistocene ice sheets. The unloading initiated an uplift of the crust close to the centers of former ice sheets. Today, vertical land motion (VLM) rates in Fennoscandia reach values up to around 10 mm/year and are dominated by GIA. Uplift signals from GIA can be computed by solving the sea-level equation (SLE), \( S' = N' - U' \). All three quantities can also be determined from geodetic observations: relative sea-level variations (\( S' \)) are observed by means of tide gauges, while rates of absolute sea-level change (\( N' \)) can be observed by satellite altimetry; rates of VLM (\( U' \)) can be determined by GPS (Global Positioning System). Based on the SLE, \( U' \) can be derived by combining sea-surface measurements from satellite altimetry and relative sea-level records from tide gauges. In the present study, we have combined 7.5 years of CryoSat-2 satellite altimetry and tide-gauge data to estimate linear VLM rates at 20 tide gauges along the Norwegian coast. Thereby, we made use of monthly averaged tide-gauge data from PSMSL (Permanent Service for Mean Sea Level) and a high-frequency tide-gauge data set with 10-min sampling rate from NMA (Norwegian Mapping Authority). To validate our VLM estimates, we have compared them with the independent semi-empirical land-uplift model NKG2016LU_abs for the Nordic-Baltic region, which is based on GPS, levelling, and geodynamical modeling. Estimated VLM rates from 1 Hz CryoSat-2 and high-frequency tide-gauge data reflect well the amplitude of coastal VLM as provided by NKG2016LU_abs. We find a coastal average of 2.4 mm/year (average over all tide gauges), while NKG2016LU_abs suggests 2.8 mm/year; the spatial correlation is 0.58.
An Integrated View of Greenland Ice Sheet Mass Changes Based on Models and Satellite Observations

The Greenland ice sheet is a major contributor to sea level rise, adding on average 0.47 ± 0.23 mm year⁻¹ to global mean sea level between 1991 and 2015. The cryosphere as a whole has contributed around 45% of observed global sea level rise since 1993. Understanding the present-day state of the Greenland ice sheet is therefore vital for understanding the processes controlling the modern-day rates of sea level change and for making projections of sea level rise into the future. Here, we provide an overview of the current state of the mass budget of Greenland based on a diverse range of remote sensing observations to produce the essential climate variables (ECVs) of ice velocity, surface elevation change, grounding line location, calving front location, and gravimetric mass balance as well as numerical modelling that together build a consistent picture of a shrinking ice sheet. We also combine these observations with output from a regional climate model and from an ice sheet model to gain insight into existing biases in ice sheet dynamics and surface mass balance processes. Observations show surface lowering across virtually all regions of the ice sheet and at some locations up to −2.65 m year⁻¹ between 1995 and 2017 based on radar altimetry analysis. In addition, calving fronts at 28 study sites, representing a sample of typical glaciers, have retreated all around Greenland since the 1990s and in only two out of 28 study locations have they remained stable. During the same period, two of five floating ice shelves have collapsed while the locations of grounding lines at the remaining three floating ice shelves have remained stable over the observation period. In a detailed case study with a fracture model at Petermann glacier, we demonstrate the potential sensitivity of these floating ice shelves to future warming. GRACE gravimetrically-derived mass balance (GMB) data shows that overall Greenland has lost 255 ± 15 Gt year⁻¹ of ice over the period 2003 to 2016, consistent with that shown by IMBIE and a marked increase compared to a rate of loss of 83 ± 63 Gt year⁻¹ in the 1993–2003 period. Regional climate model and ice sheet model simulations show that surface mass processes dominate the Greenland ice sheet mass budget over most of the interior. However, in areas of high ice velocity there is a significant contribution to mass loss by ice dynamical processes. Marked differences between models and observations indicate that not all processes are captured accurately within models, indicating areas for future research.

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Anti-glitches in the Ultraluminous Accreting Pulsar NGC 300 ULX-1 Observed with NICER

We present evidence for three spin-down glitches (or “anti-glitches”) in the ultraluminous accreting X-ray pulsar NGC 300 ULX-1, in timing observations made with the Neutron Star Interior Composition Explorer. Our timing analysis reveals three sudden spin-down events of magnitudes $\Delta \nu = -23$, $-30$, and $-43$ $\mu$Hz (fractional amplitudes $\Delta \nu/\nu = -4.4 \times 10^{-4}$, $-5.5 \times 10^{-4}$, and $-7.7 \times 10^{-4}$). We determined fully phase-coherent timing solutions through the first two glitches, giving us high confidence in their detection, while the third candidate glitch is somewhat less secure. These are larger in magnitude (and opposite in sign) than any known radio pulsar glitch. This may be caused by the prolonged rapid spin up of the pulsar, causing a sudden transfer of angular momentum between the superfluid and non-superfluid components of the star. We find no evidence for profile or spectral changes at the epochs of the glitches, supporting the conclusion that these are due to the same process as in normal pulsar glitches, but in reverse.

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ATLAS probe: Breakthrough science of galaxy evolution, cosmology, Milky Way, and the Solar System

Astrophysics Telescope for Large Area Spectroscopy Probe is a concept for a National Aeronautics and Space Administration probe-class space mission that will achieve ground-breaking science in the fields of galaxy evolution, cosmology, Milky Way, and the Solar System. It is the follow-up space mission to Wide Field Infrared Survey Telescope (WFIRST), boosting its scientific return by obtaining deep 1–4 $\mu$m slit spectroscopy for $\sim$70% of all galaxies imaged by the $\sim$2,000 deg2 WFIRST High Latitude Survey at $z > 0.5$. Astrophysics Telescope for Large Area Spectroscopy will measure accurate and precise redshifts for $\sim$200 M galaxies out to $z < 7$, and deliver spectra that enable a wide range of diagnostic studies of the physical properties of galaxies over most of cosmic history. Astrophysics Telescope for Large Area Spectroscopy Probe and WFIRST together will produce a 3D map of the Universe over 2,000 deg2, the definitive data sets for studying galaxy evolution, probing dark matter, dark energy and modifications of General Relativity, and quantifying the 3D structure and stellar content of the Milky Way. Astrophysics Telescope for Large Area Spectroscopy Probe science spans four broad categories: (1) Revolutionising galaxy evolution studies by tracing the relation between galaxies and dark matter from galaxy groups to cosmic voids and filaments, from the epoch of reionisation through the peak era of galaxy assembly; (2) Opening a new window into the dark Universe by weighing the dark matter filaments using 3D weak lensing with spectroscopic redshifts, and obtaining definitive measurements of dark energy and modification of General Relativity using galaxy clustering; (3) Probing the Milky Way’s dust-enshrouded regions, reaching the far side of our Galaxy; and (4) Exploring the formation history of the outer Solar System by characterising Kuiper Belt Objects. Astrophysics Telescope for Large Area Spectroscopy Probe is a 1.5 m telescope with a field of view of 0.4 deg2, and uses digital micro-mirror devices as slit selectors. It has a spectroscopic resolution of $R = 1,000$, and a wavelength range of 1–4 $\mu$m. The lack of slit spectroscopy from space over a wide field of view is the obvious gap in current and planned future space missions. Astrophysics Telescope for Large Area Spectroscopy fills this big gap with an unprecedented spectroscopic capability based on digital micro-mirror devices (with an estimated spectroscopic multiplex factor greater than 5,000). Astrophysics Telescope for Large Area Spectroscopy is designed to fit within the National Aeronautics and Space Administration probe-class space mission cost envelope; it has a single instrument, a telescope
aperture that allows for a lighter launch vehicle, and mature technology (we have identified a path for digital micro-mirror devices to reach Technology Readiness Level 6 within 2 yr). Astrophysics Telescope for Large Area Spectroscopy Probe will lead to transformative science over the entire range of astrophysics: from galaxy evolution to the dark Universe, from Solar System objects to the dusty regions of the Milky Way.

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**Broad Absorption Line Disappearance/Emergence in Multiple Ions in a Weak Emission-line Quasar**

We report the discovery of the disappearance of Mg ii, Al iii, C iv, and Si iv broad absorption lines (BALs) at the same velocity (0.07c), accompanied by a new C iv BAL emerging at a higher velocity (up to 0.11c), in the quasar J0827+4252 at z = 2.038. This is the first report of BAL disappearance (i) over Mg ii, Al iii, C iv, and Si iv ions and (ii) in a weak emission-line quasar (WLQ). The discovery is based on four spectra from the Sloan Digital Sky Survey and one follow-up spectrum from Hobby-Eberly Telescope/Low-Resolution Spectrograph-2. The simultaneous C iv BAL disappearance and emergence at different velocities, together with no variations in the Catalina Real-Time Transient Survey light curve, indicate that ionization changes in the absorbing material are unlikely to cause the observed BAL variability. Our analyses reveal that transverse motion is the most likely dominant driver of the BAL disappearance/emergence. Given the presence of mildly relativistic BAL outflows and an apparently large C iv emission-line blueshift that is likely associated with strong bulk outflows in this WLQ, J0827+4252 provides a notable opportunity to study extreme quasar winds and their potential in expelling material from inner to large-scale regions.

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Characterization of the in-flight properties of the Planck telescope

The European Space Agency's Planck satellite was launched on 14 May 2009, and surveyed the sky stably and continuously between August 2009 and October 2013. The scientific analysis of the Planck data requires understanding the optical response of its detectors, which originates partly from a physical model of the optical system. In this paper, we use in-flight measurements of planets within similar to 1 degrees of boresight to estimate the geometrical properties of the telescope and focal plane. First, we use observed grating lobes to measure the amplitude of mechanical dimpling of the reflectors, which is caused by the hexagonal honeycomb structure of the carbon fibre reflectors. We find that the dimpling amplitude on the two reflectors is larger than expected from the ground, by 20% on the secondary and at least a factor of 2 on the primary. Second, we use the main beam shapes of 26 detectors to investigate the alignment of the various elements of the optical system, as well as the large-scale deformations of the reflectors. We develop a metric to guide an iterative fitting scheme, and are able to determine a new geometric model that fits the in-flight measurements better than the pre-flight prediction according to this metric. The new alignment model is within the mechanical tolerances expected from the ground, with some specific but minor exceptions. We find that the reflectors contain large-scale sinusoidal deformations most probably related to the mechanical supports. In spite of the better overall fit, the new model still does not fit the beam measurements at a level compatible with the needs of cosmological analysis. Nonetheless, future analysis of the Planck data would benefit from taking into account some of the features of the new model. The analysis described here exemplifies some of the limitations of in-flight retrieval of the geometry of an optical system similar to that of Planck, and provides useful information for similar efforts in future experiments.

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Characterizing Jupiter's energetic (>15 MeV) particle environment with the Juno MAG investigation's micro Advanced Stellar Compass

NASA's Juno mission entered into polar orbit about Jupiter on July 4th, 2016. Since then 17 science orbits have been completed, systematically mapping the 3D magnetosphere of Jupiter for the first time. Located on the tip of one of Juno's three solar arrays, the Magnetic Field Experiment carries an absolute attitude reference sensor, the fully autonomous "micro Advances Stellar Compass" (μASC) designed and built at the Technical University of Denmark.

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Coherent X-ray Diffractive Imaging Simulated by Monte Carlo Ray-Tracing

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Cold gas in the early Universe - Survey for neutral atomic-carbon in GRB host galaxies at 1 < z < 6 from optical afterglow spectroscopy

We present a survey for neutral atomic-carbon (CI) along gamma-ray burst (GRB) sightlines, which probes the shielded neutral gas-phase in the interstellar medium (ISM) of GRB host galaxies at high redshift. We compile a sample of 29 medium- to high-resolution GRB optical afterglow spectra spanning a redshift range through most of cosmic time from 1 < z < 6. We find that seven (≈25%) of the GRBs entering our statistical sample have CI detected in absorption. It is evident that there is a strong excess of cold gas in GRB hosts compared to absorbers in quasar sightlines. We investigate the dust properties of the GRB CI absorbers and find that the amount of neutral carbon is positively correlated with the visual extinction, AV, and the strength of the 2175 Å dust extinction feature, A bump. GRBs with CI detected in absorption are all observed above a certain threshold of logN(HI)/cm$^{-2} + [X/H]$ > 20.7 and a dust-phase iron column density of logN(Fe)_{dust}/cm$^{-2}$ > 16.2. In contrast to the SED-derived dust properties, the strength of the CI absorption does not correlate with the depletion-derived dust properties. This indicates that the GRB CI absorbers trace dusty systems where the dust composition is dominated by carbon-rich dust grains. The observed higher metal and dust column densities of the GRB CI absorbers compared to H2- and CI-bearing quasar absorbers is mainly a consequence of how the two absorber populations are selected, but is also required in the presence of intense UV radiation fields in actively star-forming galaxies.

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Contribution of the Greenland Ice Sheet to sea level over the next millennium
The Greenland Ice Sheet holds 7.2 m of sea level equivalent and in recent decades, rising temperatures have led to accelerated mass loss. Current ice margin recession is led by the retreat of outlet glaciers, large rivers of ice ending in narrow fjords that drain the interior. We pair an outlet glacier-resolving ice sheet model with a comprehensive uncertainty quantification to estimate Greenland's contribution to sea level over the next millennium. We find that Greenland could contribute 5 to 33 cm to sea level by 2100, with discharge from outlet glaciers contributing 8 to 45% of total mass loss. Our analysis shows that uncertainties in projecting mass loss are dominated by uncertainties in climate scenarios and surface processes, whereas uncertainties in calving and frontal melt play a minor role. We project that Greenland will very likely become ice free within a millennium without substantial reductions in greenhouse gas emissions.

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Deciphering an evolutionary sequence of merger stages in infrared-luminous starburst galaxies at $z \sim 0.7$

Based on optical and near-IR Magellan FIRE spectra of 25 starburst galaxies at $0.5 < z < 0.9$, a recent publication showed that their attenuation properties can be explained by a single-parameter sequence of total obscurations ranging from $A_V = 2$ to $A_V = 30$ toward the starburst core centers in a mixed stars and dust configuration. We investigate here the origin of this sequence for the same sample. We show that total attenuations anticorrelate with the starburst sizes in radio (3 GHz) with a significance larger than 5σ and a scatter of 0.26 dex. More obscured and compact starbursts also show enhanced $N2 (=\text{[NII]/H}\alpha)$ ratios and larger line velocity widths that we attribute to an increasing shock contribution toward later merger phases, driven by deeper gravitational potential wells at the coalescence. Additionally, the attenuation is also linked to the equivalent width (EW) of hydrogen recombination lines, which is sensitive to the luminosity weighted age of the relatively unobscured stellar populations. Overall, the correlations among $A_V$, total radio size, line width, $N2$ and $EW$ of Balmer and Paschen lines converge toward suggesting an evolutionary sequence of merger stages: all of these quantities are likely to be good time-tracers of the merger phenomenon, and their large spanned range appears to be characteristic of the different merger phases. Half of our sample at higher obscurations have radio sizes approximately 3 times smaller than early type galaxies at the same redshift, suggesting that, in analogy with local ultraluminous infrared galaxies (ULIRGs), these cores cannot be directly forming elliptical galaxies. Finally, we detect mid-IR AGN torus for half of our sample and additional X-ray emission for 6 starbursts; intriguingly, the latter have systematically more compact sizes, suggestive of emerging AGNs toward later merger stages, possibly precursors of a later QSO phase.

Deep Long Asymmetric Occultation in EPIC 204376071

We have discovered a young M star of mass $0.16 \, M_\odot$ and radius $0.63 \, R_\odot$, likely in the Upper Sco Association, that exhibits only a single 80% deep occultation of 1-day duration. The star has frequent flares and a low-amplitude rotational modulation, but is otherwise quiet over 160 days of cumulative observation during K2 Campaigns C2 and C15. We
discuss how such a deep eclipse is not possible by one star crossing another in any binary or higher-order stellar system in which no mass transfer has occurred. The two possible explanations we are left with are (1) orbiting dust or small particles (e.g., a disk bound to a smaller orbiting body, or unbound dust that emanates from such a body); or (2) a transient accretion event of dusty material near the corotation radius of the star. In either case, the time between such occultation events must be longer than ~80 days. We model a possible orbiting occulter both as a uniform elliptically shaped surface (e.g., an inclined circular disk) and as a ‘dust sheet’ with a gradient of optical depth behind its leading edge. The required masses in such dust features are then $\gtrsim 3 \times 10^{19}$ g and $\gtrsim 10^{19}$ g, for the two cases, respectively.

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**Dense matter with eXTP**

In this White Paper we present the potential of the Enhanced X-ray Timing and Polarimetry (eXTP) mission for determining the nature of dense matter; neutron star cores host an extreme density regime which cannot be replicated in a terrestrial laboratory. The tightest statistical constraints on the dense matter equation of state will come from pulse profile modelling of accretion-powered pulsars, burst oscillation sources, and rotation-powered pulsars. Additional constraints will derive from spin measurements, burst spectra, and properties of the accretion flows in the vicinity of the neutron star. Under development by an international Consortium led by the Institute of High Energy Physics of the Chinese Academy of Sciences, the eXTP mission is expected to be launched in the mid 2020s.

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Corresponding author: Watts, A. L.
Evaluation of a Compton camera concept using the 3D CdZnTe drift strip detectors
At DTU Space, a high-resolution 3D CZT drift strip detector has been developed and a number of prototype detectors were fabricated, allowing for sub-mm position resolution at high energies (> 100 keV), as well as high energy resolution. For spectral and spatial performance, the 3D CZT prototype detectors were characterized with a fine collimated high-energy (Cs137) monochromatic beam (0.2 mm x 40 mm) using a digitizer with which the pulse shapes of the bipolar signals from all electrodes could be analysed. Data analysis consist of position determination for single as well as double interaction events handled within the detector. The double interaction events (e.g. Compton interaction) are utilized to characterize the imaging performance of the 3D CZT drift strip detector prototype when operating as a Compton camera.

Global marine gravity field modelling using satellite altimetry has been undergoing constant improvement since the launch of Cryosat-2 mission in 2010. With its 369 day-repeat Cryosat-2 provides one repeat of geodetic mission data with 8 km global resolution each year. Together with the completion of the Jason-1 end-of-life geodetic mission in 2011 and 2012, these new satellites has provided more than three times three times as much geodetic missions altimetric sea surface height observations than ever before. The higher precision of these new sea surface height observations compared with observations from ERS-1 and Geosat results in a dramatic improvement of the shorter wavelength of the gravity field
(12–20 km) resulting in much favorable comparison with marine gravity. The pan-Arctic altimetric gravity field now surpassing 2008 Arctic Gravity Field project derived from multiple gravity field sources. A direct comparison between Arctic marine gravity fields and independent gravity field from the Gravity Field and Steady-State Ocean Circulation Explorer to degree and order 280 confirms this.

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Firn data compilation reveals widespread decrease of firn air content in western Greenland

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Geodetic and model data reveal different spatio-temporal patterns of transient mass changes over Greenland from 2007 to 2017

Much of the research to understand the ice mass changes of Greenland ice sheet (GrIS) has focused on detecting linear rates and accelerations at decadal or longer periods. The transient (short-term, non-secular) mass changes show large variability, and if not properly accounted for, can introduce significant biases into estimates of long-term ice mass loss rates and accelerations. Despite the growing number of geodetic observations, in terms of spatial coverage, types of observables, and the extent of the time series, studies of the transient mass changes over GrIS are lacking. To address this limitation, we apply multi-channel singular spectral analysis to the Gravity Recovery and Climate Experiment (GRACE) mass concentrations (mascon), surface mass balance (SMB) model output, and ice discharge data, to determine the transient mass changes over Greenland over the decade (2007 to 2017). The goal of this analysis is to elucidate the spatio-temporal variability of the ice mass change. For the entire GrIS, both the mascon and SMB transient mass changes are characterized by a sustained mass gain from late 2007 to early 2010, a sustained mass loss from early 2010 to early 2013, and a mass gain from early 2013 to mid-2015. Global Positioning System sites deployed along the coast of Greenland showed uplift from early 2010 to early 2013 and subsidence from early 2013 to 2015, consistent with the corresponding ice mass loss and gain of the entire GrIS. The peak-to-peak amplitude of the transient mass change was estimated to be −294 ± 27 Gt from GRACE mascons and -252 ± 16 Gt from the SMB where the latter value includes the effect of ice discharge. The transient mass change due to ice discharge accounted for less than 10% of the total transient mass change. Our regional assessment reveals that the central-west, southwest, northeast, and southeast regions display similar time-varying patterns as we found for the entire GrIS, but the north and northwest regions show different patterns. Atmospheric circulation anomalies as measured by the Greenland Blocking Index (GBI) are able to explain most of these transient anomalies. More specifically, high-GBI-associated high temperature was one of the main reasons for the transient mass loss of the entire GrIS during 2010-2012 while low GBI can explain the transient mass gain during 2013-2015. Contrasting behaviors of precipitation anomalies in east and west Greenland under abnormally high or low GBI conditions may explain the different patterns of the transient mass change in the northwest and the rest of Greenland.

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Geomagnetic jerks and rapid hydromagnetic waves focusing at Earth’s core surface

Geomagnetic jerks are abrupt changes in the second time derivative—the secular acceleration—of Earth’s magnetic field that punctuate ground observatory records. As their dynamical origin has not yet been established, they represent a major obstacle to the prediction of geomagnetic field behaviour for years to decades ahead. Recent jerks have been linked to short-lived, temporally alternating and equatorially localized pulses of secular acceleration observed in satellite data, associated with rapidly alternating flows at Earth’s core surface. Here we show that these signatures can be reproduced in numerical simulations of the geodynamo that realistically account for the interaction between slow core convection and rapid hydromagnetic waves. In these simulations, jerks are caused by the arrival of localized Alfvén wave packets radiated from sudden buoyancy releases inside the core. As they reach the core surface, the waves focus their energy towards the equatorial plane and along lines of strong magnetic flux, creating sharp interannual changes in core flow and producing geomagnetic jerks through the induced variations in magnetic field acceleration. The ability to numerically reproduce jerks offers a new way to probe the physical properties of Earth’s deep interior.

GEOMED2: High-Resolution Geoid of the Mediterranean

Geoid models for the Mediterranean were computed using the remove-compute-restore method and Stokes-FFT, using shipborne gravity or altimetry inferred gravity data over sea and land gravity data. The remove step over sea does not include residual terrain correction (bathymetry), which leads to slightly worse results. The models were compared to an independent geoid constructed by subtracting the Mean Dynamic Topography from the Mean Sea Surface, and secondly to drifter-observed current speeds. Results revealed significant errors in the gravimetric geoid at smallest scales, and analysis of the results of this intermediate model showed that improvement is required in the gravity data preprocessing, specifically the de-biasing of marine data, as well as the gridding (interpolation) procedure. These issues will be addressed before the release of the final geoid model early 2018. Based on the drifter comparisons, the geoid based on altimeter data is the most accurate, more accurate than EIGEN6C4, and notably so at scales less than 50 km.
Gold–carbonyl group interactions in the electrochemistry of anthraquinone thiols self-assembled on Au(111)-surfaces

New anthraquinone derivatives with either a single or two thiol groups (AQ1 and AQ2) were synthesized and immobilized in self-assembled monolayers (SAMs) on Au(111) electrodes via Au–S bonds. The resultant AQ1- and AQ2-SAMs were studied by cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS), which enabled mapping of the gold–carbonyl group interactions and other dynamics in the Au–S bound molecular framework. Understanding of these interactions is important for research on thiol-coated gold nanoclusters, since (I) anthraquinone derivatives are a major compound family for providing desired redox functionality in multifarious assays or devices, and (II) the gold–carbonyl interactions can strongly affect anthraquinone electrochemistry. Based on equivalent circuit analysis, it was found that there is a significant rise in polarization resistance (related to SAM structural reorganization) at potentials that can be attributed to the quinone/semi-quinone interconversion. The equivalent circuit model was validated by calculation of pseudocapacitance for quinone-to-hydroquinone interconversion, in good agreement with the values derived from CV. The EIS and CV patterns obtained provide consistent evidence for two different ECET (i.e. proton-controlled ET steps, PCET) pathways in AQ1- and AQ2-SAMs. Notably, it was found that the formal reorganization (free) energies obtained for the elementary PCET steps are unexpectedly small for both SAMs studied. This anomaly suggests high layer rigidity and recumbent molecular orientation on gold surfaces, especially for the AQ2-SAMs. The results strongly indicate that gold–carbonyl group interactions can be controlled by favorable structural organization of anthraquinone-based molecules on gold surfaces.
Greenland Ice Sheet solid ice discharge from 1986 through 2017
We present a 1986 through 2017 estimate of Greenland Ice Sheet ice discharge. Our data include all discharging ice that flows faster than 100 m yr$^{-1}$ and are generated through an automatic and adaptable method, as opposed to conventional hand-picked gates. We position gates near the present-year termini and estimate problematic bed topography (ice thickness) values where necessary. In addition to using annual time-varying ice thickness, our time series uses velocity maps that begin with sparse spatial and temporal coverage and end with near-complete spatial coverage and 6d updates to velocity. The 2010 through 2017 average ice discharge through the flux gates is $\sim$488±49 Gt yr$^{-1}$. The 10% uncertainty stems primarily from uncertain ice bed location (ice thickness). We attribute the $\sim$50 Gt yr$^{-1}$ differences among our results and previous studies to our use of updated bed topography from BedMachine v3. Discharge is approximately steady from 1986 to 2000, increases sharply from 2000 to 2005, and then is approximately steady again. However, regional and glacier variability is more pronounced, with recent decreases at most major glaciers and in all but one region offset by increases in the NW (northwestern) region.

HARPS-N radial velocities confirm the low densities of the Kepler-9 planets
We investigated the discrepancy between planetary mass determination using the transit timing variations (TTVs) and radial velocities (RVs), by analysing the multi-planet system Kepler-9. Despite being the first system characterised with TTVs, there are several discrepant solutions in the literature, with those reporting lower planetary densities being apparently in disagreement with high-precision RV observations. To resolve this, we gathered HARPS-N RVs at epochs that maximised the difference between the predicted RV curves from discrepant solutions in the literature. We also re-analysed the full Kepler data-set and performed a dynamical fit, within a Bayesian framework, using the newly derived central and duration times of the transits. We compared these results with the RV data and found that our solution better describes the RV observations, despite the masses of the planets being nearly half that presented in the discovery paper. We therefore confirm that the TTV method can provide mass determinations that agree with those determined using high-precision RVs. The low densities of the planets place them in the scarcely populated region of the super-Neptunes / inflated sub-Saturns in the mass-radius diagram.
HD 202772A b: A Transiting Hot Jupiter around a Bright, Mildly Evolved Star in a Visual Binary Discovered by TESS

We report the first confirmation of a hot Jupiter discovered by the Transiting Exoplanet Survey Satellite (TESS) mission: HD 202772A b. The transit signal was detected in the data from TESS Sector 1, and was confirmed to be of planetary origin through radial velocity (RV) measurements. HD 202772A b is orbiting a mildly evolved star with a period of 3.3 days. With an apparent magnitude of $V = 8.3$, the star is among the brightest and most massive known to host a hot Jupiter. Based on the 27 days of TESS photometry and RV data from the CHIRON, HARPS, and Tillinghast Reflector Echelle Spectrograph, the planet has a mass of $1.017^{+0.070}_{-0.068} M_J$ and radius of $1.545^{+0.052}_{-0.060} R_J$, making it an inflated gas giant. HD 202772A b is a rare example of a transiting hot Jupiter around a quickly evolving star. It is also one of the most strongly irradiated hot Jupiters currently known.
Hidden or missing outflows in highly obscured galaxy nuclei?

Context. Understanding the nuclear growth and feedback processes in galaxies requires investigating their often obscured central regions. One way to do this is to use (sub)millimeter line emission from vibrationally excited HCN (HCN-vib), which is thought to trace warm and highly enshrouded galaxy nuclei. It has been suggested that the most intense HCN-vib emission from a galaxy is connected to a phase of nuclear growth that occurs before the nuclear feedback processes have been fully developed.

Aims. We aim to investigate if there is a connection between the presence of strong HCN-vib emission and the development of feedback in (ultra)luminous infrared galaxies ((U)LIRGs).

Methods. We collected literature and archival data to compare the luminosities of rotational lines of HCN-vib, normalized to the total infrared luminosity, to the median velocities of 119 μm OH absorption lines, potentially indicating outflows, in a total of 17 (U)LIRGs.

Results. The most HCN-vib luminous systems all lack signatures of significant molecular outflows in the far-infrared OH absorption lines. However, at least some of the systems with bright HCN-vib emission have fast and collimated outflows that can be seen in spectral lines at longer wavelengths, including in millimeter emission lines of CO and HCN (in its vibrational ground state) and in radio absorption lines of OH.

Conclusions. We conclude that the galaxy nuclei with the highest $L_{\text{HCN-vib}}/L_{\text{IR}}$ do not drive wide-angle outflows that are detectable using the median velocities of far-infrared OH absorption lines. This is possibly because of an orientation effect in which sources oriented in such a way that their outflows are not along our line of sight also radiate a smaller proportion of their infrared luminosity in our direction. It could also be that massive wide-angle outflows destroy the deeply embedded regions responsible for bright HCN-vib emission, so that the two phenomena cannot coexist. This would strengthen the idea that vibrationally excited HCN traces a heavily obscured stage of evolution before nuclear feedback mechanisms are fully developed.

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High spatial resolution monitoring land surface energy, water and CO₂ fluxes from an Unmanned Aerial System

High spatial resolution maps of land surface energy, water and CO₂ fluxes, e.g. evapotranspiration (ET) and gross primary productivity (GPP), are important for agricultural monitoring, ecosystem and water resources management. However, it is not clear which is the optimal (e.g. coarsest possible) spatial resolution to capture those fluxes accurately. Unmanned Aerial Systems (UAS) can address this by collecting very high spatial resolution (<1 m, VHR) imagery. The objective of this study is to model ET and GPP dynamics using VHR optical and thermal imagery and quantify the influence of the spatial heterogeneity in the flux simulations and validations. The study was conducted at a deciduous willow bioenergy eddy covariance (EC) flux site in Denmark. Flight campaigns were conducted during the growing seasons of 2016 and 2017 with a hexacopter equipped with RGB, multispectral and thermal infrared cameras. A ‘top-down’ modeling approach consisting of the Priestley–Taylor Jet Propulsion Laboratory model and a light use efficiency model sharing the same canopy biophysical constraints was used to estimate ET and GPP. Model outputs were benchmarked by EC flux observations with the source weighted footprint. Our results indicate that our model can well estimate the instantaneous net radiation, ET, GPP, evaporative fraction, light use efficiency and water use efficiency with root-mean-square deviations (RMSD) of 31.6 W·m⁻², 41.2 W·m⁻², 3.12 μmol·C·m⁻²·s⁻¹, 0.08, 0.16 g·C·MJ⁻¹·aand 0.35 g·C·kg⁻¹, respectively. Further, it is found that using a footprint model to sample different areas of VHR imagery can be a tool to provide better diurnal estimates to benchmark with EC data. Moreover, these VHR maps (0.3 m) allowed us to quantify metrics of spatial heterogeneity by using semivariogram analysis and by aggregating model inputs into different spatial resolutions. For instance, we find that in this site, the aggregation of simulated GPP using the source weighted mean of the EC footprint was about 30% lower in RMSD than using the arithmetic mean of the footprint. This demonstrates the accuracy of the modeled VHR spatial patterns. Nevertheless, we also find that imagery resolution consistent with the canopy size (around 1.5 m in our study) is sufficient to capture the spatial heterogeneity of the fluxes as transpiration and canopy assimilation of CO₂ are processes regulated at the tree crown level. Our results highlight the importance of considering the land surface heterogeneity for flux modeling and the source contribution within the EC footprint for model benchmarking at appropriate spatial resolutions.

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Ice dynamics of union glacier from SAR offset tracking
The Antarctic ice sheet is predicted to be the major contributor to sea-level rise during the XXI century. Therefore, monitoring ice dynamics of outlet glaciers in Antarctica is of great importance to assess future sea-level rise predictions. Union Glacier is one of the major outlet glaciers of the Ellsworth Mountains and drains into the Ronne-Filchner Ice Shelf. Glaciers can be studied using remote-sensing techniques, which combined with field measurements can deliver a good approximation of its dynamics and can be used as input for glacier models. In this study we acquired high resolution Stripmap HIMAGE SAR images from the COSMO-SkyMed satellite constellation during austral summer of 2011–2012, and applied a SAR offset tracking algorithm to compute ice velocities. Then, we compared our derived velocities with field data already published. Results showed mean values of ice velocity estimated for the main trunk of the glacier are 0.043 (0.0393 SD) m d⁻¹, with values reaching up to 0.325 m d⁻¹, in agreement with previous studies. A model of ice thickness based on lamellar flow theory is proposed, using estimated surface ice velocity in combination with surface slope derived from TanDEM-X as input data. Comparison of our modeled ice thickness with radar data agree with a mean absolute deviation of 19.22%. From surface ice velocities we computed principal strain rates in order to assess crevasse formation and closure. Thereafter, using high resolution COSMO-SkyMed Spotlight-2 SAR images we establish a relation between surface features and acting strain components.
Chandra-HETGS Characterization of an Outflowing Wind in the Accreting Millisecond Pulsar IGR J17591–2342

An accreting millisecond X-ray pulsar, IGR J17591–2342 was discovered in 2018 August in scans of the Galactic bulge and center by the International Gamma-Ray Astrophysics Laboratory X-ray and gamma-ray observatory. It exhibited an unusual outburst profile with multiple peaks in the X-ray, as observed by several X-ray satellites over 3 months. Here we present observations of this source performed in the X-ray/gamma-ray and near-infrared domains and focus on a simultaneous observation performed with the Chandra High Energy Transmission Gratings Spectrometer (HETGS) and the Neutron Star Interior Composition Explorer (NICER). The HETGS provides high-resolution spectra of the Si edge region that yield clues as to the source’s distance and reveal evidence (at 99.999% significance) of an outflow with a velocity of 2800 km s⁻¹. We demonstrate good agreement between the NICER and HETGS continua, provided that one properly accounts for the differing manners in which these instruments view the dust-scattering halo in the source’s foreground. Unusually, we find a possible set of Ca lines in the HETGS spectra (with significances ranging from 97.0% to 99.7%). We hypothesize that IGR J17591–2342 is a neutron star low-mass X-ray binary at the distance of the Galactic bulge or beyond that may have formed from the collapse of a white dwarf system in a rare, calcium-rich Type Ib supernova explosion.
IGR J17503–2636: a candidate supergiant fast X-ray transient

The object IGR J17503–2636 is a hard X-ray transient discovered by INTEGRAL on 2018 August 11. This was the first ever reported X-ray emission from this source. Following the discovery, follow-up observations were carried out with Swift, Chandra, NICER, and NuSTAR. Here we report on the analysis of all of these X-ray data and the results obtained. Based on the fast variability in the X-ray domain, the spectral energy distribution in the 0.5–80 keV energy range, and the reported association with a highly reddened OB supergiant at ∼10 kpc, we conclude that IGR J17503–2636 is most likely a relatively faint new member of the supergiant fast X-ray transients. Spectral analysis of the NuSTAR data revealed a broad feature in addition to the typical power-law with exponential roll-over at high energy. This can be modeled either in emission or as a cyclotron scattering feature in absorption. If confirmed by future observations, this feature would indicate that IGR J17503–2636 hosts a strongly magnetized neutron star with B ∼ 2 × 10^{12} G.

HSTF160W Imaging of Very Massive Galaxies at 1.5 < z < 3.0: Diversity of Structures and the Effect of Close Pairs on Number Density Estimates

We present a targeted follow-up Hubble Space Telescope WFC3 F160W imaging study of very massive galaxies (logM_{star}/M_{⊙}) > 11.25 selected from a combination of ground-based near-infrared galaxy surveys (UltraVISTA, NEWFIRM Medium Band Survey-II, UKIRT Infrared Deep Sky Survey (UKIDSS) Ultra-Deep Survey (UDS) at 1.5 < z < 3). We find that these galaxies are diverse in their structures, with ~1/3 of the targets being composed of close pairs, and span a wide range in sizes. At 1.5 < z < 2.5, the sizes of both star-forming and quiescent galaxies are consistent with the extrapolation of the stellar mass–size relations determined at lower stellar masses. At 2.5 < z < 3.0, however, we find evidence that quiescent galaxies are systematically larger than expected based on the extrapolation of the relation derived using lower stellar mass galaxies. We used the observed light profiles of the blended systems to decompose their stellar masses and investigate the effect of the close pairs on the measured number densities of very massive galaxies in the early universe. We estimate correction factors to account for close-pair blends and apply them to the observed stellar mass functions (SMFs) measured using ground-based surveys. Given the large uncertainties associated with this extreme population of galaxies, there is currently little tension between the (blending-corrected) number density estimates and predictions from theoretical models. Although we currently lack the statistics to robustly correct for close-pair blends, we show that this is a systematic effect that can reduce the observed number density of very massive galaxies by up to a factor of ~1.5, and should be accounted for in future studies of SMFs.
Improved search for solar chameleons with a GridPix detector at CAST

We report on a new search for solar chameleons with the CERN Axion Solar Telescope (CAST). A GridPix detector was used to search for soft X-ray photons in the energy range from 200 eV to 10 keV from converted solar chameleons. No significant excess over the expected background has been observed in the data taken in 2014 and 2015. We set an improved limit on the chameleon photon coupling, \( \beta \#5.7\times10^{10} \) for \( 1<\beta_{m}<10^{6} \) at 95% C.L. improving our previous results by a factor two and for the first time reaching sensitivity below the solar luminosity bound for tachocline magnetic fields up to 12.5 T.

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Corresponding author: Krieger, C.
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We present new timing and spectral analyses of PSR J1412+7922 (Calvera) and PSR J1849-0001, which are only seen as pulsars in X-rays, based on observations conducted with the Neutron Star Interior Composition Explorer. We obtain updated and substantially improved pulse ephemerides compared to previous X-ray studies, as well as spectra that can be well fit by simple blackbodies and/or a power law. Our refined timing measurements enable deeper searches for pulsations at other wavelengths and sensitive targeted searches by the Laser Interferometer Gravitational-Wave Observatory (LIGO)/Virgo for continuous gravitational waves from these neutron stars. Using the sensitivity of LIGO’s first observing run, we estimate constraints that a gravitational wave search of these pulsars would be obtained on the size of their mass deformation and r-mode fluid oscillation.

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Corresponding author: Bogdanov, S.
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**Influence of local geoid variation on water surface elevation estimates derived from multi-mission altimetry for Lake Namco**
Water surface elevation (WSE) is an essential quantity for water resource monitoring and hydrodynamic modeling. Satellite altimetry has provided data for inland water bodies. The height that is derived from altimetry measurement is ellipsoidal height. In order to convert the ellipsoidal height to orthometric height, which has physical meaning, accurate estimates of the geoid are needed. This paper evaluates the suitability of geodetic altimetric measurements for improvement of global geoid models over a large lake in the Tibetan Plateau. CryoSat-2 and SARAL/AltiKa are used to derive the high-frequency geoid correction. A validation of the local geoid correction is performed with data from in-situ observations, a laser altimetry satellite (ICESat), a Ka-band radar altimetry satellite (SARAL) and a SAR radar altimetry satellite (Sentinel-3). Results indicate that the geodetic altimetric dataset can capture the high-resolution geoid information. By applying local geoid correction, the precision of ICESat, SARAL and Sentinel-3 retrievals are significantly improved. We conclude that using geodetic altimetry to correct for local geoid residual over large lakes significantly decreases the uncertainty of WSE estimates. These results also indicate the potential of geodetic altimetry missions to...
determine local geoid residual with centimeter-level accuracy, which can be used to improve global and regional geopotential models.

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Publication status: Published
Organisations: Department of Environmental Engineering, Air, Land & Water Resources, National Space Institute, Geodesy, Chinese Academy of Sciences
Corresponding author: Jiang, L.
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**NICER Discovers Spectral Lines during Photospheric Radius Expansion Bursts from 4U 1820−30: Evidence for Burst-driven Winds**

We report the discovery with the Neutron Star Interior Composition Explorer (NICER) of narrow emission and absorption lines during photospheric radius expansion (PRE) X-ray bursts from the ultracompact binary 4U 1820−30. NICER observed 4U 1820−30 in 2017 August during a low-flux, hard spectral state, accumulating about 60 ks of exposure. Five thermonuclear X-ray bursts were detected, of which four showed clear signs of PRE. We extracted spectra during the PRE phases and fit each to a model that includes a Comptonized component to describe the accretion-driven emission, and a blackbody for the burst thermal radiation. The temperature and spherical emitting radius of the fitted blackbody are used to assess the strength of PRE in each burst. The two strongest PRE bursts (burst pair 1) had blackbody temperatures of ≈0.6 keV and emitting radii of ≈100 km (at a distance of 8.4 kpc). The other two bursts (burst pair 2) had higher temperatures (≈0.67 keV) and smaller radii (≈75 km). All of the PRE bursts show evidence of narrow line emission near 1 keV. By coadding the PRE phase spectra of burst pairs 1 and, separately, 2, we find, in both coadded spectra, significant, narrow, spectral features near 1.0 (emission), 1.7, and 3.0 keV (both in absorption). Remarkably, all the fitted line centroids in the coadded spectrum of burst pair 1 appear systematically blueshifted by a factor of 1.046 ± 0.006 compared to the centroids of pair 2, strongly indicative of a gravitational shift, a wind-induced blueshift, or more likely some combination of both effects. The observed shifts are consistent with this scenario in that the stronger PRE bursts in pair 1 reach larger photospheric radii, and thus have weaker gravitational redshifts, and they generate faster outflows, yielding higher blueshifts. We discuss possible elemental identifications for the observed features in the context of recent burst-driven wind models.

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NICER Observation of Unusual Burst Oscillations in 4U 1728-34

The Neutron Star Interior Composition Explorer has observed seven thermonuclear X-ray bursts from the low-mass X-ray binary neutron star 4U 1728–34 from the start of the mission’s operations until 2019 February. Three of these bursts show oscillations in their decaying tail, with frequencies that are within 1 Hz of the previously detected burst oscillations from this source. Two of these burst oscillations have unusual properties: they have large fractional root mean square (rms) amplitudes of 48% ± 9% and 46% ± 9%, and they are detected only at photon energies above 6 keV. By contrast, the third detected burst oscillation is compatible with previous observations of this source, with a fractional rms amplitude of 7.7% ± 1.5% rms in the 0.3 to 6.2 keV energy band. We discuss the implications of these large-amplitude burst oscillations, finding that they are difficult to explain with the current theoretical models for X-ray burst tail oscillations.

NICER Observations of the 2018 Outburst of XTE J1810-197

We present the earliest available soft X-ray observations of XTE J1810-197, the prototypical transient magnetar, obtained 75-84 days after its 2018 outburst with the Neutron Star Interior Composition Explorer. Using a series of observations covering eight days we find that its decreasing X-ray flux is well described by either a blackbody plus power law or a two-blackbody spectral model. The 2-10 keV flux of the source varied from (1.206 +/- 0.007) x 10^{-10} to (1.125 +/- 0.004) x 10^{-10} erg s^{-1} cm^{-2}, a decrease of about 7% within our observations and 44% from that measured 7-14 days after the outburst with NuSTAR. We confirm that the pulsed fraction and spin pulse phase of the neutron star are energy dependent up to at least 8 keV. Phase-resolved spectroscopy of the pulsar suggests magnetospheric variations relative to the line of sight.

NICER Observations of the 2018 Outburst of XTE J1810-197

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Innovative Multi-Feed-Per-Beam Reflector Antenna for Space-Borne Conical-Scan Radiometers

We present an antenna for use on conical-scan space-borne radiometers in C band and demonstrate that stringent radiometric requirements can be met. The antenna consists of as m offset reflector fed by a focal plane array in a multi-feed-per-beam configuration, so far never used in ocean observation missions. We use distinct element beams and two optimization routines for obtaining element excitation amplitudes and phases, and with either routine, and in both x- and y-polarization, compliant beams, with footprint < 20 km, distance to coast < 20 km and accuracy < 0.25 K, are obtained. These results may pave the way for use of focal plane arrays with digital beamforming in future radiometric ocean observation missions.

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Contributors: de Lasson, J. R., Cappelin, C., Pontoppidan, K., Iupikov, O., Ivashina, M., Skou, N., Fiorelli, B.
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In situ observed relationships between snow and ice surface skin temperatures and 2 m air temperatures in the Arctic

To facilitate the construction of a satellite-derived 2 m air temperature($T_{2m}$) product for the snow- and ice-covered regions in the Arctic, observations from weather stations are used to quantify the relationship between the $T_{2m}$ and skin temperature($T_{skin}$). Multyear data records of simultaneous $T_{2m}$ and $T_{skin}$ from 29 different in situ sites have been analysed for five regions, covering the lower and upper ablation zone and the accumulation zone of the Greenland Ice
Sheet (GrIS), sea ice in the Arctic Ocean, and seasonal snow-covered land in northern Alaska. The diurnal and seasonal temperature variabilities and the impacts from clouds and wind on the $T_{2m} - T_{skin}$ differences are quantified. $T_{skin}$ is often (85% of the time, all sites weighted equally) lower than $T_{2m}$, with the largest differences occurring when the temperatures are well below 0 °C or when the surface is melting. Considering all regions, $T_{2m}$ is on average 0.65–2.65 °C higher than $T_{skin}$, with the largest differences for the lower ablation area and smallest differences for the seasonal snow-covered sites. A negative net surface radiation balance generally cools the surface with respect to the atmosphere, resulting in a surface-driversurface air temperature inversion. However, $T_{skin}$ and $T_{2m}$ are often highly correlated, and the two temperatures can be almost identical (<0.5 °C difference), with the smallest $T_{2m} - T_{skin}$ differences around noon and early afternoon during spring, autumn and summer during non-melting conditions. In general, the inversion strength increases with decreasing wind speeds, but for the sites on the GrIS the maximum inversion occurs at wind speeds of about 5 m s$^{-1}$ due to the katabatic winds. Clouds tend to reduce the vertical temperature gradient, by warming the surface, resulting in a mean overcast $T_{2m} - T_{skin}$ difference ranging from −0.08 to 1.63 °C, with the largest differences for the sites in the low-ablation zone and the smallest differences for the seasonal snow-covered sites. To assess the effect of using cloud-limited infrared satellite observations, the influence of clouds on temporally averaged $T_{skin}$ has been studied by comparing averaged clear-sky $T_{skin}$ with averaged all-sky $T_{skin}$. To this end, we test three different temporal averaging windows: 24 h, 72 h and 1 month. The largest clear-sky biases are generally found when 1-month averages are used and the smallest clear-sky biases are found for 24 h. In most cases, all-sky averages are warmer than clear-sky averages, with the smallest bias during summer when the $T_{skin}$ range is smallest.

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**K2-140b and K2-180b – Characterization of a hot Jupiter and a mini-Neptune from the K2 mission**

We report the independent discovery and characterization of two K2 planets: K2-180b, a mini-Neptune-sized planet in an 8.9-d orbit transiting a $V=12.6$ mag, metal-poor ([Fe/H] $= -0.65 \pm 0.10$) K2V star in K2 campaign 5; K2-140b, a transiting hot Jupiter in a 6.6-d orbit around a $V=12.6$ mag G6V ([Fe/H] $= +0.10 \pm 0.10$) star in K2 campaign 10. Our results are based on K2 time-series photometry combined with high-spatial resolution imaging and high-precision radial velocity measurements. We present the first mass measurement of K2-180b. K2-180b has a mass of $M_p = 11.3 \pm 1.9 M_{\oplus}$ and a radius of $R_p = 2.2 \pm 0.1 R_{\oplus}$, yielding a mean density of $\rho_p = 5.6 \pm 1.9 g cm^{-3}$, suggesting a rocky composition. Given its radius, K2-180b is above the region of the so-called ‘planetary radius gap’. K2-180b is in addition not only one of the densest mini-Neptune-sized planets, but also one of the few mini-Neptune-sized planets known to transit a metal-poor star. We also constrain the planetary and orbital parameters of K2-140b and show that, given the currently available Doppler measurements, the eccentricity is consistent with zero, contrary to the results of a previous study.

**General information**

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Organisations: Astrophysics and Atmospheric Physics, National Space Institute, Universität zu Köln, German Aerospace Center, University of Turin, Chalmers University of Technology, Leiden University, Tokyo Institute of Technology, University of Tokyo, University of La Laguna, Aarhus University, University of Texas at Austin, Princeton University, Wesleyan University, Thüringer Landessternwarte Tautenburg, National Institute for Astrophysics, National Astronomical Observatory of Japan, University of Groningen
Local Averages of the Core-mantle Boundary Magnetic Field from Satellite Observations

We introduce a formalism for estimating local spatial averages of the core-mantle boundary (CMB) radial magnetic field and its time derivatives, based on magnetic field observations collected by low-Earth-orbit satellites. This provides a useful alternative to conventional core field modelling based on global spherical harmonic basis functions, where noise in the polar regions maps into all harmonics, and model regularization and spectral truncation are required. A powerful perspective offered by the proposed technique is formal appraisal of the spatial resolution and variance of the resulting field averages. We use the Green’s functions for the Neumann boundary value problem to link the satellite observations to the radial magnetic field on the CMB and estimate field averages using a modified Backus-Gilbert inversion approach. Our approach builds on the Subtractive Optimally Localized Averages (SOLA) method developed in helioseismology, that seeks averaging kernels as close as possible to a chosen target kernel. We are able to account for both internal and external field sources and can easily incorporate data error covariance information, for example describing along-track serial error correlation. As a proof of concept we present a global map collecting local estimates of the radial main field (MF) constructed on a grid at the CMB with one degree spacing in latitude and longitude, derived from one month of three component vector magnetic field data collected by the Swarm satellite trio, using data from dark and geomagnetically quiet times. Using sums and differences of the field components taken along track and in the east-west direction we obtain estimates with spatial resolution kernel widths varying between 18 and 54 degrees depending on the latitude, and a standard deviation of approximately 10μT (i.e. 5% of the mean CMB field amplitude). The morphology of our CMB radial field map agrees well with results from conventional spherical harmonic field models. In a second application, we determine local estimates of the average rate of change, or secular variation (SV), of the radial field at the CMB, initially considering two year time windows, and performing the analysis on data collected by either the Swarm or CHAMP satellites. We obtain stable local estimates of the SV at the CMB, and present maps of estimates with averaging kernel widths of approximately 42, 33 and 30 degrees on the equator, with corresponding standard derivations of 0.25, 2.5 and 5 μT/yr. By subtracting SV estimates constructed at different epochs we are able to calculate the local aggregated secular acceleration (SA) and to study its time changes. Differencing SV estimates 2 years apart, and considering an averaging kernel width of 42 degrees on the equator, we obtain SA maps very similar to those found in the CHAOS-6-x7 field model truncated at SH degree 10. Using our approach we are able to directly control the width of the spatial averaging kernel and the length of the time window, enabling us to directly study the robustness of the inferred SA. Pushing to higher resolution in time, considering one year differences of SV estimates constructed using one year windows, we are able to track the evolution of coherent SA structures in time-longitude plots at the equator. At 25° W in mid 2007 we find a distinctive SA ‘cross-over’ event, with strong, oppositely signed and adjacent, SA features rapidly changing sign within a year. Our method is well suited for studying such spatio-temporally localized SA events at high resolution; there will be further opportunities for such investigations as the time series of data provided by the Swarm mission lengthens.
Masses and radii for the three super-Earths orbiting GJ 9827, and implications for the composition of small exoplanets

Super-Earths belong to a class of planet not found in the Solar System, but which appear common in the Galaxy. Given that some super-Earths are rocky, while others retain substantial atmospheres, their study can provide clues as to the formation of both rocky planets and gaseous planets, and - in particular - they can help to constrain the role of photo-evaporation in sculpting the exoplanet population. GJ 9827 is a system already known to host 3 super-Earths with orbital periods of 1.2, 3.6 and 6.2 days. Here we use new HARPS-N radial velocity measurements, together with previously published radial velocity measurements, to better constrain the properties of the GJ 9827 planets. Our analysis can't place a strong constraint on the mass of GJ 9827 c, but does indicate that GJ 9827 b is rocky with a composition that is probably similar to that of the Earth, while GJ 9827 d almost certainly retains a volatile envelope. Therefore, GJ 9827 hosts planets on either side of the radius gap that appears to divide super-Earths into predominantly rocky ones that have radii below \( \sim 1.5\, R_\oplus \) and ones that still retain a substantial atmosphere and/or volatile components, and have radii above \( \sim 2R_\oplus \). That the less heavily irradiated of the 3 planets still retains an atmosphere, may indicate that photo-evaporation has played a key role in the evolution of the planets in this system.

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Organisations: Astrophysics and Atmospheric Physics, National Space Institute, University of California at Berkeley, University of Edinburgh, National Institute for Astrophysics, University of Cambridge, University of Texas at Austin, Harvard-Smithsonian Center for Astrophysics, Harvard University, University of St Andrews, Queen's University Belfast, Université de Genève, Fundación Galileo Galilei, Universita di Padova, European Southern Observatory, NASA Goddard Space Flight Center
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Measuring Coseismic Deformation With Spaceborne Synthetic Aperture Radar: A Review

In the past 25 years, space-borne Synthetic Aperture Radar imagery has become an increasingly available data source for the study of crustal deformation associated with moderate to large earthquakes (M > 4.0). Coseismic surface deformation can be measured with several well-established techniques, the applicability of which depends on the ground displacement pattern, on several radar parameters, and on the surface properties at the time of the radar acquisitions. The state-of-the-art concerning the measurement techniques is reviewed, and their application to over 100 case-studies since the launch of the Sentinel-1a satellite is discussed, including the performance of the different methods and the data processing aspects, which still constitute topics of ongoing research.

General information
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Organisations: National Space Institute
Corresponding author: Peter Merryman Boncori, J.
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Research output: Contribution to journal › Review – Annual report year: 2019 › Research › peer-review

Mind Controlled Drone: An Innovative Multiclass SSVEP based Brain Computer Interface

A crucial element lost in the context of a neurodegenerative disease is the possibility to freely explore and interact with the world around us. The work presented in this paper is focused on developing a brain-controlled Assistive Device (AD) to aid individuals in exploring the world around them with the help of a computer and their thoughts. By using the potential of a noninvasive Steady-State Visual Evoked Potential (SSVEP)-based Brain Computer Interface (BCI) system, the users can control a flying robot (also known as UAV or drone) in 3D physical space. From a video stream received from a video camera mounted on the drone, users can experience a degree of freedom while controlling the drone in 3D. The system proposed in this study uses a consumer-oriented headset, known as Emotiv Epoch in order to record the electroencephalogram (EEG) data. The system was tested on ten able-bodied subjects where four distinctive SSVEPs (5.3 Hz, 7 Hz, 9.4 Hz and 13.5 Hz) were detected and used as control signals for actuating the drone. A highly customizable visual interface was developed in order to elicit each SSVEP. The data recorded was filtered with an 8th order Butterworth bandpass filter and a fast Fourier transform (FFT) spectral analysis of the signal was applied in other to detect and classify each SSVEP. The proposed BCI system resulted in an average Information Transfer Rate (ITR) of 10
bits/min and a Positive Predictive Value (PPV) of 92.5%. The final conducted tests have demonstrated that the system proposed in this paper can easily control a drone in 3D space.

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Contributors: Chiuzbaian, A., Jakobsen, J., Puthusserypady, S.
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**Molecular and Ionized Gas Phases of an AGN-driven Outflow in a Typical Massive Galaxy at z ≈ 2**
Nuclear outflows driven by accreting massive black holes are one of the main feedback mechanisms invoked at high-z to reproduce the distinct separation between star-forming disk galaxies and quiescent spheroidal systems. Yet our knowledge of feedback at high-z remains limited by the lack of observations of the multiple gas phases in galaxy outflows. In this work, we use new deep, high spatial resolution ALMA CO(3-2) and archival Very Large Telescope/SINFONI Hα observations to study the molecular and ionized components of the active galactic nucleus (AGN)-driven outflow in zC400528, a massive main-sequence galaxy at z = 2.3 in the process of quenching. We detect a powerful molecular outflow that shows a positive velocity gradient before a turnover and extends for at least similar to 10 kpc from the nuclear region, about three times the projected size of the ionized wind. The molecular gas in the outflow does not reach velocities high enough to escape the galaxy and is therefore expected to be reaccreted. Keeping in mind the various assumptions involved in the analysis, we find that the mass and energetics of the outflow are dominated by the molecular phase. The AGN-driven outflow in zC400528 is powerful enough to deplete the molecular gas reservoir on a timescale comparable to that needed to exhaust it by star formation. This suggests that the nuclear outflow is one of the main quenching engines at work in the observed suppression of the central star formation activity in zC400528.

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Monte Carlo Ray Tracing of Scanning Coherent Diffractive Imaging

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Corresponding author: Andreasen, J. W.
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Observatory science with eXTP
In this White Paper we present the potential of the enhanced X-ray Timing and Polarimetry (eXTP) mission for studies related to Observatory Science targets. These include flaring stars, supernova remnants, accreting white dwarfs, low and high mass X-ray binaries, radio quiet and radio loud active galactic nuclei, tidal disruption events, and gamma-ray bursts. eXTP will be excellently suited to study one common aspect of these objects: their often transient nature. Developed by an international Consortium led by the Institute of High Energy Physics of the Chinese Academy of Science, the eXTP mission is expected to be launched in the mid 2020s.

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Corresponding author: in ’t Zand, J. J. M.
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On the Curious Pulsation Properties of the Accreting Millisecond Pulsar IGR J17379-3747

We report on the Neutron Star Interior Composition Explorer (NICER) monitoring campaign of the 468 Hz accreting millisecond X-ray pulsar IGR J17379-3747. From a detailed spectral and timing analysis of the coherent pulsations we find that they show a strong energy dependence, with soft thermal emission lagging about 640 µs behind the hard, Comptonized emission. Additionally, we observe uncommonly large pulse fractions, with measured amplitudes in excess of 20% sinusoidal fractional amplitude across the NICER passband and fluctuations of up to similar to 70%. Based on a phase-resolved spectral analysis, we suggest that these extreme properties might be explained if the source has an unusually favorable viewing geometry with a large magnetic misalignment angle. Due to these large pulse fractions, we were able to detect pulsations down to quiescent luminosities (similar to 5 x 10^33 erg s^-1). We discuss these low-luminosity pulsations in the context of transitional millisecond pulsars.

Optical constants of magnetron sputtered Pt thin films with improved accuracy in the N- and O-electronic shell absorption regions

We present an experimental, self-consistent determination of the optical constants (refractive index) of Pt using a combination of photoabsorption and reflectance data in the photon energy range 25–778 eV, which includes the N- and O-shell electronic absorption edges of Pt. We compare our new experimental values with Pt optical constant data sets from the literature. Our Pt optical constant values reveal highly resolved absorption-edge fine structure around the O2,3 and N 6,7 edges in both the absorptive and dispersive portions of the refractive index, which were missing in the earlier literature.
Oscillations in the Sun with SONG: Setting the scale for asteroseismic investigations

Context. We present the first high-cadence multiwavelength radial-velocity observations of the Sun-as-a-star, carried out during 57 consecutive days using the stellar échelle spectrograph at the Hertzsprung SONG Telescope operating at the Teide Observatory. Aims. Our aim was to produce a high-quality data set and reference values for the global helioseismic parameters $v_{\text{max}}$ and $\Delta v$ of the solar p-modes using the SONG instrument. The obtained data set or the inferred values should then be used when the scaling relations are applied to other stars showing solar-like oscillations observed with SONG or similar instruments. Methods. We used different approaches to analyse the power spectrum of the time series to determine $v_{\text{max}}$: simple Gaussian fitting and heavy smoothing of the power spectrum. We determined $\Delta v$ using the method of autocorrelation of the power spectrum. The amplitude per radial mode was determined using the method described in Kjeldsen et al. (2008, ApJ, 682, 1370). Results. We found the following values for the solar oscillations using the SONG spectrograph: $v_{\text{max}} = 3141 \pm 12 \muHz$, $\Delta v = 134.98 \pm 0.04 \muHz$, and an average amplitude of the strongest radial modes of $16.6 \pm 0.4 \cm s^{-1}$. These values are consistent with previous measurements with other techniques.

Patchy Lakes and Topographic Origin for Fast Flow in the Recovery Glacier System, East Antarctica

The Recovery subglacial basin, with its largest glacier Recovery Glacier, has been identified as potentially the biggest contributor to future sea level rise from East Antarctica. Subglacial lakes along the main trunk have been detected from satellite data, with four giant lakes (Recovery Lakes A, B, C, and D) located at the onset of the fast ice flow ($\geq 15 \m/yr$) and...
multiple smaller lakes along the glacier. The presence of subglacial water potentially plays a key role in the control of fast ice flow of Recovery Glacier. We present new insights on the Recovery Lakes from airborne radar data collected in 2013 and 2015. Using an adjusted classification scheme, we show that a single large area consisting of smaller lakes connected by likely saturated sediment, referred to as Lake AB, exists in the originally proposed area of the Recovery Lakes A and B. We estimate that the current size of Lake AB is ~4,320 km². Water likely leaks from the western shore of Lake AB lubricating the bed initiating fast ice flow at this location. The difference in the outlines of Lake AB and the Lakes A and B previously derived from surface features suggested that a larger paleolake existed here in the past. From our data, we find Recovery Lake C to be dry; we attribute fast ice flow originating from this area to be due to a topographic step and thus an increase in ice thickness rather than enhanced lubrication at the bed.

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Photodynamical analysis of the triply eclipsing hierarchical triple system EPIC 249432662
Using Campaign 15 data from the K2 mission, we have discovered a triply-eclipsing triple star system: EPIC 249432662. The inner eclipsing binary system has a period of 8.23 days, with shallow ~3% eclipses. During the entire 80-day campaign, there is also a single eclipse event of a third-body in the system that reaches a depth of nearly 50% and has a total duration of 1.7 days, longer than for any previously known third-body eclipse involving unevolved stars. The binary eclipses exhibit clear eclipse timing variations. A combination of photodynamical modeling of the lightcurve, as well as seven follow-up radial velocity measurements, has led to a prediction of the subsequent eclipses of the third star with a period of 188 days. A campaign of follow-up ground-based photometry was able to capture the subsequent pair of third-body events as well as two further 8-day eclipses. A combined photo-spectro-dynamical analysis then leads to the determination of many of the system parameters. The 8-day binary consists of a pair of M stars, while most of the system light is from a K star around which the pair of M stars orbits.

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Organisations: National Space Institute, University of California at Berkeley, Hungarian Academy of Sciences, Massachusetts Institute of Technology, Raemor Vista Observatory, Harvard-Smithsonian Center for Astrophysics, California Institute of Technology, Perth Exoplanet Survey Telescope, NASA Goddard Space Flight Center, Ruhr-Universität Bochum, University of Texas at Austin
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Pages: 1934–1951
Publication date: 2019
We present broad-band photometry of 11 planetary transits of the hot Jupiter WASP-74 b, using three medium-class telescopes and employing the telescope-defocusing technique. Most of the transits were monitored through I filters and one was simultaneously observed in five optical (U, g', r', i', z') and three near-infrared (J, H, K) passbands, for a total of 18 light curves. We also obtained new high-resolution spectra of the host star. We used these new data to review the orbital and physical properties of the WASP-74 planetary system. We were able to better constrain the main system characteristics, measuring smaller radius and mass for both the hot Jupiter and its host star than previously reported in the literature. Joining our optical data with those taken with the HST in the near infrared, we built up an observational transmission spectrum of the planet, which suggests the presence of strong optical absorbers, as TiO and VO gases, in its atmosphere.
Postglacial gravity change in Fennoscandia – three decades of repeated absolute gravity observations

For the first time, we present a complete, processed compilation of all repeated absolute gravity (AG) observations in the Fennoscandian postglacial land uplift area and assess their ability to accurately describe the secular gravity change, induced by Glacial Isostatic Adjustment (GIA). The dataset spans over more than three decades and consists of 688 separate observations at 59 stations. Ten different organisations have contributed with measurements using 14 different instruments. The work was coordinated by the Nordic Geodetic Comission (NKG). Representatives from each country collected and processed data from their country, respectively, and all data were then merged to one dataset. Instrumental biases are considered and presented in terms of results from international comparisons of absolute gravimeters. From this dataset, gravity rates of change (g˙) are estimated for all stations with more than two observations and a timespan larger than two years. The observed rates are compared to predicted rates from a global GIA model as well as the state of the art semi-empirical land uplift model for Fennoscandia, NKG2016LU. Linear relations between observed g˙ and the land uplift, h˙ (NKG2016LU), are estimated from the absolute gravity observations by means of weighted least squares adjustment (WLSA) as well as weighted orthogonal distance regression (WODR). The empirical relations are not significantly different from the modelled, geophysical relation g˙ = 0.03–0.163(±0.016)h˙. We also present a g˙-model for the whole Fennoscandian land uplift region. At many stations, the observational estimates of g˙ still suffer from few observations and/or unmodelled environmental effects (e.g. local hydrology). We therefore argue that, at present, the best predictions of GIA-induced gravity rate of change in Fennoscandia are achieved by means of the NKG2016LU land uplift model, together with the geophysical relation between g˙ and h˙.

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Source-ID: 2443538373
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Resolving Seasonal Ice Velocity of 45 Greenlandic Glaciers With Very High Temporal Details
Seasonal glacier ice velocities are important for understanding controlling mechanisms of ice flow. For many Greenlandic glaciers, however, these measurements are limited by low temporal resolution. We present seasonal ice velocity changes, melt season onset and extent, and ice front positions for 45 Greenlandic glaciers using 2015–2017 Sentinel-1 synthetic aperture radar data. Seasonal velocity fluctuations of roughly half of the glaciers appear to be primarily controlled by surface melt-induced changes in the subglacial hydrology. This includes (1) glaciers that speed up with the onset of surface melt and (2) glaciers with comparable late winter and early melt season velocities that show significant slowdown during most of the melt season and speedup during winter. In contrast, less than a quarter of the study glaciers show strong correspondence between seasonal ice speed and terminus changes. Our results pinpoint seasonal variations across Greenland, highlighting the variable influence of meltwater on year-round ice velocities.

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Retrieving Sea Level and Freeboard in the Arctic: A Review of Current Radar Altimetry Methodologies and Future Perspectives
Spaceborne radar altimeters record echo waveforms over all Earth surfaces, but their interpretation and quantitative exploitation over the Arctic Ocean is particularly challenging. Radar returns may be from all ocean, all sea ice, or a mixture of the two, so the first task is the determination of which surface and then an interpretation of the signal to give range. Subsequently, corrections have to be applied for various surface and atmospheric effects before making a comparison with a reference level. This paper discusses the drivers for improved altimetry in the Arctic and then reviews the various approaches that have been used to achieve the initial classification and subsequent retracking over these diverse surfaces, showing examples from both LRM (low resolution mode) and SAR (synthetic aperture radar) altimeters. The review then discusses the issues concerning corrections, including the choices between using other remote-sensing measurements and using those from models or climatology. The paper finishes with some perspectives on future developments, incorporating secondary frequency, interferometric SAR and opportunities for fusion with measurements from laser altimetry or from the SMOS salinity sensor, and provides a full list of relevant abbreviations.

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Satellite Forensics: Analysing Sparse Beacon Data to Reveal the Fate of DTUsat-2
The CubeSat DTUsat-2 was designed and built by students and faculty at the Technical University of Denmark and launched to low earth orbit on June 2014. Its mission was to aid ornithologists in bird migration research. Shortly after launch and orbit injection, it became apparent that all was not nominal. To understand the problem and find the causes, a forensic investigation was initiated. The investigation used recorded Morse-encoded beacons emitted by the satellite as a starting point. This paper presents the real-life data from DTUsat-2 on orbit and the methodologies used to visualize the key element in the investigation, namely, the correlation between orbit position and the beacon counter. Based on the data presented, an explanation for the observed behaviour of DTUsat-2 is given.

Self-luminous and irradiated exoplanetary atmospheres explored with HELIOS
We present new methodological features and physical ingredients included in the one-dimensional radiative transfer code HELIOS, improving the hemispheric two-stream formalism. We conduct a thorough intercomparison survey with several established forward models, including COOLTLUSTY and PHOENIX, and find satisfactory consistency with their results. Then, we explore the impact of (i) different groups of opacity sources, (ii) a stellar path length adjustment, and (iii) a scattering correction on self-consistently calculated atmospheric temperatures and planetary emission spectra. First, we observe that temperature–pressure (T–P) profiles are very sensitive to the opacities included, with metal oxides, hydrides, and alkali atoms (and ionized hydrogen) playing an important role in the absorption of shortwave radiation (in very hot surroundings). Moreover, if these species are sufficiently abundant, they are likely to induce nonmonotonic T–P profiles. Second, without the stellar path length adjustment, the incoming stellar flux is significantly underestimated for zenith angles above 80°, which somewhat affects the upper atmospheric temperatures and the planetary emission. Third, the scattering correction improves the accuracy of the computation of the reflected stellar light by ~10%. We use HELIOS to calculate a grid of cloud-free atmospheres in radiative-convective equilibrium for self-luminous planets for a range of...
effective temperatures, surface gravities, metallicities, and C/O ratios to be used by planetary evolution studies. Furthermore, we calculate dayside temperatures and secondary eclipse spectra for a sample of exoplanets for varying chemistry and heat redistribution. These results may be used to make predictions on the feasibility of atmospheric characterizations with future observations.

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Organisations: National Space Institute, Astrophysics and Atmospheric Physics, University of Bern
Contributors: Malik, M., Kitzmann, D., Mendonça, J. M., Grimm, S. L., Marieau, G., Linder, E. F., Tsai, S., Heng, K.
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**Ship-Iceberg Detection & Classification in Sentinel-1 SAR Images**
The European Space Agency Sentinel-1 satellites provide good resolution all weather SAR images. We describe algorithms for detection and classification of ships, icebergs and other objects at sea. Sidelobes from strongly reflecting objects as large ships are suppressed for better determination of ship parameters. The resulting improved ship lengths and breadths are larger than the ground truth values known from Automatic Identification System (AIS) data due to the limited resolution in the processing of the SAR images as compared to previous analyses of Sentinel-2 optical images. The limited resolution in SAR imagery degrades spatial classification algorithms but it is found that the backscatter horizontal and vertical polarizations can be exploited to distinguish icebergs in the Arctic from large ships but not small boats or wakes.

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**Signatures of a jet cocoon in early spectra of a supernova associated with a γ-ray burst**
Long γ-ray bursts are associated with energetic, broad-lined, stripped-envelope supernovae and as such mark the death of massive stars. The scarcity of such events nearby and the brightness of the γ-ray burst afterglow, which dominates the emission in the first few days after the burst, have so far prevented the study of the very early evolution of supernovae associated with γ-ray bursts. In hydrogen-stripped supernovae that are not associated with γ-ray bursts, an excess of high-velocity (roughly 30,000 kilometres per second) material has been interpreted as a signature of a choked jet, which did not emerge from the progenitor star and instead deposited all of its energy in a thermal cocoon. Here we report multi-epoch spectroscopic observations of the supernova SN 2017iuk, which is associated with the γ-ray burst GRB 171205A. Our spectra display features at extremely high expansion velocities (around 115,000 kilometres per second) within the first day after the burst. Using spectral synthesis models developed for SN 2017iuk, we show that
these features are characterized by chemical abundances that differ from those observed in the ejecta of SN 2017iuk at later times. We further show that the high-velocity features originate from the mildly relativistic hot cocoon that is generated by an ultra-relativistic jet within the γ-ray burst expanding and decelerating into the medium that surrounds the progenitor star. This cocoon rapidly becomes transparent and is outshone by the supernova emission, which starts to dominate the emission three days after the burst.

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So close, so different: characterization of the K2-36 planetary system with HARPS-N
Context. K2-36 is a K dwarf orbited by two small (Rb = 1.43 ± 0.08 R⊕ and Rc = 3.2 ± 0.3 R⊕), close-in (ab = 0.022 au and ac = 0.054 au) transiting planets discovered by the Kepler/K2 space observatory. They are representatives of two distinct families of small planets (Rp < 4 R⊕) recently emerged from the analysis of Kepler data, with likely a different structure, composition and evolutionary pathways.
Aims. We revise the fundamental stellar parameters and the sizes of the planets, and provide the first measurement of their masses and bulk densities, which we use to infer their structure and composition.
Methods. We observed K2-36 with the HARPS-N spectrograph over ~3.5 yr, collecting 81 useful radial velocity measurements. The star is active, with evidence for increasing levels of magnetic activity during the observing time span. The radial velocity scatter is ~17 m s−1 due to the stellar activity contribution, which is much larger that the semi-amplitudes of the planetary signals. We tested different methods for mitigating the stellar activity contribution to the radial velocity time variations and measuring the planet masses with good precision.
Results. We find that K2-36 is likely a ~1 Gyr old system, and by treating the stellar activity through a Gaussian process regression, we measured the planet masses mb = 3.9 ± 1.1 M⊕ and mc = 7.8 ± 2.3 M⊕. The derived planet bulk densities ρb = 7.2±2.1 g cm−3 and pc = 1.3±0.5 g cm−3 point out that K2-36 b has a rocky, Earth-like composition, and K2-36 c is a low-density sub-Neptune.
Conclusions. Composed of two planets with similar orbital separations but different densities, K2-36 represents an optimal laboratory for testing the role of the atmospheric escape in driving the evolution of close-in, low-mass planets after ~1 Gyr from their formation. Due to their similarities, we performed a preliminary comparative analysis between the systems K2-36 and Kepler-36, which we deem worthy of a more detailed investigation.

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Space Debris Detection and Tracking Using Star Trackers

The near Earth space environment is becoming crowded with space debris and must be regarded a critical resource for future spacecraft missions. To ensure continuous access to this resource, future Low Earth orbit users have responsibility, both for savvy usage, as well as to contribute knowledge of the environment. The latter can be achieved employing a novel technique for debris population characterization, at low cost and high fidelity, applied to instruments on future as well as existing spacecraft. Star trackers traditionally provide arc-second attitude recovery for spacecraft navigation by matching observed star positions in source images to an on-board star catalogue. Typically, the 10-20k brightest stars are included in the matching, effectively enabling the star tracker to detect celestial objects with visual magnitude levels as faint as mV 7-9. Relative motion of debris is different from the apparent motion of the star field, wherefore the star tracker autonomously discerns the debris from true stars. Apparent position and trajectory of such debris may hence be collected. Since a great number of star trackers are readily in-orbit, global coverage may be achieved with already launched and operated hardware. At least, this functionality should be incorporated in new missions. The µASC star tracker from DTU (Technical University of Denmark) is the primary attitude sensor on-board a great number of spacecraft missions, including ESA’s Swarm triad and the MAG investigation on NASA’s Jupiter explorer JUNO. The Swarm triad provides routine diagnostic images from the nine sensors on the three segments. By employing the above mentioned technique on these images the prospective performance has been characterized. We present the sensitivity and performance of on-board debris detection and tracking augmentation of the star trackers. We also discuss methods to suppress false debris detection from e.g. locally produced temporary debris from thruster firings, as well as the potential for in-situ tracking of fellow spacecraft. Finally, we give examples of this technique used by the NASA JUNO mission detecting and tracking natural objects in orbit about Jupiter.

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Contributors: Denver, T., Benn, M., Jørgensen, J. L., Jørgensen, P. S., Herceg, M., Connerney, J. E.
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SPT0346-52 is one of the most luminous and intensely star-forming galaxies in the universe, with and . In this paper, we present ALMA observations of the 158 μm emission line in this z = 5.7 dusty star-forming galaxy. We use a pixellated lensing reconstruction code to spatially and kinematically resolve the source-plane and rest-frame 158 μm dust continuum structure at ~700 pc (~012) resolution. We discuss the deficit with a pixellated study of the L [C ii]/L FIR ratio in the source plane. We find that individual pixels within the galaxy follow the same trend found using unresolved observations of other galaxies, indicating that the deficit arises on scales 700 pc. The lensing reconstruction reveals two spatially and kinematically separated components (~1 kpc and ~500 km s⁻¹ apart) connected by a bridge of gas. Both components are found to be globally unstable, with Toomre Q instability parameters everywhere. We argue that SPT0346-52 is undergoing a major merger, which is likely driving the intense and compact star formation.

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Streamer propagation in the atmosphere of Titan and other N₂:CH₄ mixtures compared to N₂:O₂ mixtures

Streamers, thin, ionized plasma channels, form the early stages of lightning discharges. Here we approach the study of extraterrestrial lightning by studying the formation and propagation of streamer discharges in various nitrogen-methane and nitrogen-oxygen mixtures with levels of nitrogen from 20% to 98.4%. We present the friction force and breakdown fields Ek in various N₂:O₂ (Earth-like) and N₂:CH₄ (Titan-like) mixtures. The strength of the friction force is larger in N₂ :CH₄ mixtures whereas the breakdown field in mixtures with methane is half as large as in mixtures with oxygen. We use a 2.5 dimensional Monte Carlo particle-in-cell code with cylindrical symmetry to simulate the development of electron avalanches from an initial electron-ion patch in ambient electric fields between 1.5Ek and 3Ek. We compare the electron density, the electric field, the front velocities as well as the occurrence of avalanche-to-streamer transition between mixtures with methane and with oxygen. Whereas we observe the formation of streamers in oxygen in all considered cases, we observe streamer inceptions in methane for small percentages of nitrogen or large electric fields only. For large percentages of nitrogen or for small fields, ionization is not efficient enough to form a streamer channel within the length of the simulation domain. In oxygen, positive and negative streamers move faster for small percentages of nitrogen. In mixtures with methane, electron or streamer fronts move 10–100 times slower than in mixtures with oxygen; the higher the percentage of methane, the faster the fronts move. On Titan with methane percentages between 1.4% and 5%, a successful streamer inception would require a large electric field of 4.2 MV m⁻¹ (3Ek). Such large fields might not be present and explain the non-detection of Titan lightning by the Cassini/Huygens mission.

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Organisations: National Space Institute, Astrophysics and Atmospheric Physics, University of Belgrade
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Contributors: Köhn, C., Dujko, S., Chanrion, O., Neubert, T.
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TESS Discovery of an Ultra-short-period Planet around the Nearby M Dwarf LHS 3844

Data from the newly commissioned Transiting Exoplanet Survey Satellite has revealed a "hot Earth" around LHS 3844, an M dwarf located 15 pc away. The planet has a radius of 1.303 ± 0.022R⊕ and orbits the star every 11 hr. Although the existence of an atmosphere around such a strongly irradiated planet is questionable, the star is bright enough (I = 11.9, K = 9.1) for this possibility to be investigated with transit and occultation spectroscopy. The star's brightness and the planet's short period will also facilitate the measurement of the planet's mass through Doppler spectroscopy.
The ASIM Mission on the International Space Station

The Atmosphere-Space Interactions Monitor (ASIM) is an instrument suite on the International Space Station (ISS) for measurements of lightning, Transient Luminous Events (TLEs) and Terrestrial Gamma-ray Flashes (TGFs). Developed in the framework of the European Space Agency (ESA), it was launched April 2, 2018 on the SpaceX CRS-14 flight to the ISS. ASIM was mounted on an external platform of ESA's Columbus module eleven days later and is planned to take measurements during minimum 3 years. The instruments are an x- and gamma-ray monitor measuring photons from 15 keV to 20 MeV, and an array of three photometers and two cameras measuring in bands at: 180–250 nm, 337 nm and 777.4 nm. Additional objectives that can be addressed with the instruments relate to space physics like aurorae and meteors, and to Earth observation such as dust- and aerosol effects on cloud electrification. The paper describes the scientific objectives of the ASIM mission, the instruments, the mission architecture and the international collaboration supported by the ASIM Science Data Centre. ASIM is the first space mission with a comprehensive suite of instruments designed to measure TLEs and TGFs. Two companion papers describe the instruments in more detail (Østgaard et al. in Space Sci. Rev., 2019; Chanrion et al. in Space Sci. Rev., 2019).

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The Curious Case of KOI 4: Confirming Kepler’s First Exoplanet Detection

The discovery of thousands of planetary systems by Kepler has demonstrated that planets are ubiquitous. However, a major challenge has been the confirmation of Kepler planet candidates, many of which still await confirmation. One of the most enigmatic examples is KOI 4.01, Kepler’s first discovered planet candidate detection (as KOI 1.01, 2.01, and 3.01 were known prior to launch). Here we present the confirmation and characterization of KOI 4.01 (now Kepler-1658), using a combination of asteroseismology and radial velocities. Kepler-1658 is a massive, evolved subgiant (M star = 1.45 ± 0.06 M ⊙, R star = 2.89 ± 0.12 R ⊙) hosting a massive M_p = 5.88 ± 0.47 M_J, R_p = 1.07 ± 0.05 R_J) hot Jupiter that orbits every 3.85 days. Kepler-1658 joins a small population of evolved hosts with short-period (≤100 days) planets and is now the closest known planet in terms of orbital period to an evolved star. Because of its unique orbital configuration, Kepler-1658 is a new benchmark system for testing tidal dissipation and hot Jupiter formation theories. Using all four years of the Kepler data, we constrain the orbital decay rate to be P ≤ −0.42 ± 0.07 s yr−1, corresponding to a strong observational limit of Q' star ≥ 4.826 × 10^3 for the tidal quality factor in evolved stars. With an effective temperature of T_{eff} ~ 6200 K, Kepler-1658 sits close to the spin–orbit misalignment boundary at −6250 K, making it a prime target for follow-up observations to better constrain its obliquity and to provide insight into theories for hot Jupiter formation and migration.
The Eclipsing δ Scuti Star EPIC 245932119

We present the physical properties of EPIC 245932119 (K_p = +9.82) exhibiting both eclipses and pulsations from the K2 photometry. The binary modeling indicates that the eclipsing system is in detached or semi-detached configurations with a mass ratio of 0.283 or 0.245, respectively, and that its light-curve parameters are almost unaffected by pulsations. Multiple frequency analyses were performed for the light residuals in the outside-primary eclipsing phase after subtracting the binarity effects from the observed data. We detected 35 frequencies with signal-to-noise amplitude ratios larger than 4.0 in two regions of 0.62-6.28 day^{-1} and 19.36-24.07 day^{-1}. Among these, it is possible that some high signals close to the Nyquist limit f(Ny) may be reflections of real pulsation frequencies (2f_{Ny} - f_1). All frequencies (f_8, f_9, f_{14}, f_{18}, f_{24}, f_{29}) in the lower frequency region are orbital harmonics, and three high frequencies (f_{19}, f_{20}, f_{22}) appear to be sidelobes split from the main frequency of f_1 = 22.77503 day^{-1}. Most of them are thought to be alias effects caused by the orbital frequency. For the 26 other frequencies, the pulsation periods and pulsation constants are in the ranges of 0.041-0.052 days and 0.013-0.016 days, respectively. These values and the position in the Hertzsprung-Russell diagram reveal that the primary component is a delta Scuti pulsator. The observational properties of EPIC 245932119 are in good agreement with those for eclipsing binaries with delta Scuti-type pulsating components.
The enhanced X-ray Timing and Polarimetry mission—eXTP
In this paper we present the enhanced X-ray Timing and Polarimetry mission—eXTP. eXTP is a space science mission designed to study fundamental physics under extreme conditions of density, gravity and magnetism. The mission aims at determining the equation of state of matter at supra-nuclear density, measuring effects of QED, and understanding the dynamics of matter in strong-field gravity. In addition to investigating fundamental physics, eXTP will be a very powerful observatory for astrophysics that will provide observations of unprecedented quality on a variety of galactic and extragalactic objects. In particular, its wide field monitoring capabilities will be highly instrumental to detect the electromagnetic counterparts of gravitational wave sources. The paper provides a detailed description of: (1) the technological and technical aspects, and the expected performance of the instruments of the scientific payload; (2) the elements and functions of the mission, from the spacecraft to the ground segment.

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The European Space Agency BIOMASS mission: Measuring forest above-ground biomass from space
The primary objective of the European Space Agency’s 7th Earth Explorer mission, BIOMASS, is to determine the worldwide distribution of forest above-ground biomass (AGB) in order to reduce the major uncertainties in calculations of carbon stocks and fluxes associated with the terrestrial biosphere, including carbon fluxes associated with Land Use Change, forest degradation and forest regrowth. To meet this objective it will carry, for the first time in space, a fully polarimetric P-band synthetic aperture radar (SAR). Three main products will be provided: global maps of both AGB and
forest height, with a spatial resolution of 200m, and maps of severe forest disturbance at 50m resolution (where “global” is to be understood as subject to Space Object tracking radar restrictions). After launch in 2022, there will be a 3-month commissioning phase, followed by a 14-month phase during which there will be global coverage by SAR tomography. In the succeeding interferometric phase, global polarimetric interferometry Pol-InSAR coverage will be achieved every 7 months up to the end of the 5-year mission. Both Pol-InSAR and TomoSAR will be used to eliminate scattering from the ground (both direct and double bounce backscatter) in forests. In dense tropical forests AGB can then be estimated from the remaining volume scattering using non-linear inversion of a backscattering model. Airborne campaigns in the tropics also indicate that AGB is highly correlated with the backscatter from around 30m above the ground, as measured by tomography. In contrast, double bounce scattering appears to carry important information about the AGB of boreal forests, so ground cancellation may not be appropriate and the best approach for such forests remains to be finalized. Several methods to exploit these new data in carbon cycle calculations have already been demonstrated. In addition, major mutual gains will be made by combining BIOMASS data with data from other missions that will measure forest biomass, structure, height and change, including the NASA Global Ecosystem Dynamics Investigation lidar deployed on the International Space Station after its launch in December 2018, and the NASA-ISRO NISAR L- and S-band SAR, due for launch in 2022. More generally, space-based measurements of biomass are a core component of a carbon cycle observation and modelling strategy developed by the Group on Earth Observations. Secondary objectives of the mission include imaging of sub-surface geological structures in arid environments, generation of a true Digital Terrain Model without biases caused by forest cover, and measurement of glacier and icesheet velocities. In addition, the operations needed for ionospheric correction of the data will allow very sensitive estimates of ionospheric Total Electron Content and its changes along the dawn-dusk orbit of the mission.

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The Extremely Luminous Quasar Survey in the Sloan Digital Sky Survey Footprint. III. The South Galactic Cap Sample and the Quasar Luminosity Function at Cosmic Noon
We have designed the Extremely Luminous Quasar Survey (ELQS) to provide a highly complete census of unobscured UV-bright quasars during the cosmic noon, z = 2.8-5.0. Here we report the discovery of 70 new quasars in the ELQS South Galactic Cap (ELQS-S) quasar sample, doubling the number of known extremely luminous quasars in 4237.3 deg² of the Sloan Digital Sky Survey footprint. These observations conlude the ELQS and we present the properties of the full ELQS quasar catalog, containing 407 quasars over 11,838.5 deg². Our novel ELQS quasar selection strategy resulted in unprecedented completeness at the bright end and allowed us to discover 109 new quasars in total. This marks an increase of similar to 36% (109/298) in the known population at these redshifts and magnitudes, while we further are able to retain a selection efficiency of similar to 80%. On the basis of 166 quasars from the full ELQS quasar catalog, which adhere to the uniform criteria of the Two Micron All Sky Survey point source catalog, we measure the bright-end quasar luminosity function (QLF) and extend it one magnitude brighter than previous studies. Assuming a single power law with exponential density evolution for the functional form of the QLF, we retrieve the best-fit parameters from a maximum likelihood analysis. We find a steep brightend slope of beta approximate to -4.1, and we can constrain the bright-end slope to β ≤ -3.4 with 99% confidence. The density is well modeled by the exponential redshift evolution, resulting in a moderate decrease with redshift (γ ≈ -0.4).
The host galaxy of GRB 980425 / SN1998bw: a collisional ring galaxy

We report Giant Metrewave Radio Telescope (GMRT), Very Large Telescope (VLT) and Spitzer Space Telescope observations of ESO 184–G82, the host galaxy of GRB 980425/SN 1998bw, that yield evidence of a companion dwarf galaxy at a projected distance of 13 kpc. The companion, hereafter GALJ193510-524947, is a gas-rich, star-forming galaxy with a star formation rate of 0.004M⊙yr⁻¹, a gas mass of 10⁷.1 ± 0.1M⊙, and a stellar mass of 10⁷.0 ± 0.3M⊙. The interaction between ESO 184–G82 and GALJ193510-524947 is evident from the extended gaseous structure between the two galaxies in the GMRT H i 21 cm map. We find a ring of high column density H i gas, passing through the actively star forming regions of ESO 184–G82 and the GRB location. This ring lends support to the picture in which ESO 184–G82 is interacting with GALJ193510-524947. The massive stars in GALJ193510-524947 have similar ages to those in star-forming regions in ESO 184–G82, also suggesting that the interaction may have triggered star formation in both galaxies. The gas and star formation properties of ESO 184–G82 favour a head-on collision with GALJ193510-524947 rather than a classical tidal interaction. We perform state-of-the-art simulations of dwarf–dwarf mergers and confirm that the observed properties of ESO 184–G82 can be reproduced by collision with a small companion galaxy. This is a very clear case of interaction in a gamma ray burst host galaxy, and of interaction-driven star formation giving rise to a gamma ray burst in a dense environment.
The Magnetic Signatures of the $M_2$, $N_2$, and $O_1$ Oceanic Tides Observed in Swarm and CHAMP Satellite Magnetic Data

This paper reports on new results in the determination of magnetic signals produced by oceanic tides as estimated from satellite magnetic measurements. We find that combining data from the past CHAMP (2000–2010) and the present Swarm (since 2013) satellite missions significantly improves the quality of the extracted tidal signals, in particular if along-track and cross-track magnetic “gradient” data are utilized. This allows us to determine the magnetic signature not only of the $M_2$ tide but also of the much weaker $N_2$ and $O_1$ tidal constituents. To minimize disturbances from magnetospheric and ionospheric currents, we only use data from the nightside region during geomagnetic quiet conditions and remove core, crustal, and magnetospheric field contributions as given by the CHAOS geomagnetic field model. Despite their small magnitudes, all determined tidal constituents show sensitivity to the electrical conductivity profile of the underlying mantle, enabling imaging the upper mantle below the oceans.

The Main Sequence at $z \approx 1.3$ Contains a Sizable Fraction of Galaxies with Compact Star Formation Sizes: A New Population of Early Post-starbursts?

Atacama Large Millimeter/submillimeter Array (ALMA) measurements for 93 Herschel-selected galaxies at $1.1 \leq z \leq 1.7$ in COSMOS reveal a sizable (>29%) population with compact star formation (SF) sizes, lying on average $\times3.6$ below the optical stellar mass ($M$)–size relation of disks. This sample widely spans the star-forming main sequence (MS), having $10^8 \leq M \leq 10^{11.5} M_{\odot}$ and $20 \leq$ star formation rate (SFR) $\leq 680 M_{\odot} \text{yr}^{-1}$. The 32 size measurements and 61 upper limits are measured on ALMA images that combine observations of CO(5–4), CO(4–3), CO(2–1), and $\lambda_{\text{obs}} \approx 1.1–1.3 \text{mm}$ continuum, all tracing the star-forming molecular gas. These compact galaxies have instead normally extended K band sizes, suggesting strong specific SFR gradients. Compact galaxies comprise the $50 \pm 18\%$ of MS galaxies at $M > 10^{11} M_{\odot}$. This is not expected in standard bimodal scenarios, where MS galaxies are mostly steadily growing extended disks. We suggest that compact MS objects are early post-starburst galaxies in which the merger-driven boost of SF has subsided. They retain their compact SF size until either further gas accretion restores premerger galaxy-wide SF, or until becoming quenched. The fraction of merger-affected SF inside the MS seems thus larger than anticipated and might reach ~50% at the highest $M$. The presence of large galaxies above the MS demonstrates an overall poor correlation between galaxy SF size and specific SFR.
The Modular Multispectral Imaging Array (MMIA) of the ASIM Payload on the International Space Station

The Modular Multispectral Imaging Array (MMIA) is a suite of optical sensors mounted on an external platform of the European Space Agency’s Columbus Module on the International Space Station. The MMIA, together with the Modular X- and Gamma-ray Sensor (MXGS), are the two main instruments forming the Atmosphere-Space Interactions Monitor (ASIM). The primary scientific objectives of the ASIM mission are to study thunderstorm electrical activity such as lightning, Transient Luminous Emissions (TLEs) and Terrestrial Gamma-ray Flashes (TGFs) by observing the associated emissions in the UV, near-infrared, x- and gamma-ray spectral bands. The MMIA includes two cameras imaging in 337 nm and 777.4 nm, at up to 12 frames per second, and three high-speed photometers at 180–230 nm, 337 nm and 777.4 nm, sampling at rates up to 100 kHz. The paper describes the MMIA and the aspects that make it an essential tool for the study of thunderstorms. The mission architecture is described in Neubert et al. (Space Sci. Rev. 215:26, 2019, this issue) and the MXGS instruments in Østgaard et al. (Space Sci. Rev. 215:23, 2019, this issue).
The Modular X- and Gamma-Ray Sensor (MXGS) of the ASIM Payload on the International Space Station

The Modular X- and Gamma-ray Sensor (MXGS) is an imaging and spectral X- and Gamma-ray instrument mounted on the starboard side of the Columbus module on the International Space Station. Together with the Modular Multi-Spectral Imaging Assembly (MMIA) (Chanrion et al. this issue) MXGS constitutes the instruments of the Atmosphere-Space Interactions Monitor (ASIM) (Neubert et al. this issue). The main objectives of MXGS are to image and measure the spectrum of X- and γ-rays from lightning discharges, known as Terrestrial Gamma-ray Flashes (TGFs), and for MMIA to image and perform high speed photometry of Transient Luminous Events (TLEs) and lightning discharges. With these two instruments specifically designed to explore the relation between electrical discharges, TLEs and TGFs, ASIM is the first mission of its kind. With an imaging system and a large detector area MXGS will, for the first time, allow estimation of the location of the source region and characterization of the energy spectrum of individual events. The sensors have fast readout electronics to minimize pileup effects, giving high time resolution of photon detection for comparison with measurements on μs-time scales of lightning processes measured by the MMIA and other sensors in space or on the ground. The detectors cover the large energy range of the relevant photon energies. In this paper we describe the scientific objectives, design, performance, imaging capabilities and operational modes of the MXGS instrument.

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The Pulsating Eclipsing Binary TIC 309658221 in a 7.59-day Orbit

We present a new eclipsing binary (EB) showing multiperiodic oscillations using the first three sectors of Transiting Exoplanet Survey Satellite (TESS) photometry. The eclipse and pulsation light curves of TIC 309658221 were modeled using an iterative method to obtain a consistent photometric solution. The TESS target is a circular-orbit, detached binary system with a mass ratio of 0.349, an inclination angle of 80.42°, and a temperature difference of 847 K between the components. The primary component of the system lies near the red edge of the δ Sct instability region on the main-sequence band in the Hertzsprung–Russell diagram. Multiple frequency analyses were applied to the eclipse-subtracted residuals after removing the binary effects in the observed data. These resulted in the detection of 26 frequencies, of which F1 − F6 were independent pulsation frequencies. The 20 other frequencies could be mainly caused by orbital harmonics (f5 and f11) or combination frequencies. The period ratios and pulsation constants of the F1 − F6 frequencies are in the ranges of P_{pul}/P_{orb} = 0.010-0.013 and Q =0.027–0.036 days, respectively, which are typical of δ Sct type. The results reveal that TIC 309658221 is an eclipsing δ Sct star with an orbital period of 7.5952 days and pulsation frequencies of 9.94–13.01 day⁻¹. This work demonstrates that the two-minute cadence observations of TESS are very useful for the study of pulsating EBs with multiple frequencies and low amplitudes.

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The sensitivity of sprite streamer inception on the initial electron‐ion patch

Sprite streamers are bright atmospheric phenomena above thunderstorms powered by sufficiently high electric fields and free charges from inhomogeneities in the mesosphere or ionosphere. A common feature of recent simulations is that they model the streamer inception from spherical Gaussian electron-ion patches. We here tackle the question: How do the streamer inception time and streamer properties depend on the initial geometry? Therefore, we consider prolate (“cigar”) and oblate (“pancake”) electron-ion patches aiming to understand the geometric influence on streamer inception speed, electric field evolution, branching time, and ohmic heating of streamers. We initiate patches of different geometry with fixed peak densities of 5·10¹¹ m⁻³ or with a fixed total electron number of 9.40·10¹² in ambient fields of 0.5 and 1.5 times the breakdown field and study the streamer evolution between 60 and 80 km altitude with a 2.5D cylindrical Monte Carlo particle code. We present the evolution of the electron density and of the electric field. In our simulations, the time for the electric field tips to develop into the regime where they can self sustain the discharge is shortest for streamers from prolate patches and longest for oblate patches. The branching time of negative fronts depends on the eccentricity and increases for oblate patches ranging from 5 μs to 8 μs. We observe ohmic heating with maximum temperature differences up to tens of K depending on the eccentricity and density of the initial patch influencing the efficiency of plasma reactions in streamer channels.

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The sensitivity of sprite streamer inception on the initial electron‐ion patch

Sprite streamers are bright atmospheric phenomena above thunderstorms powered by sufficiently high electric fields and free charges from inhomogeneities in the mesosphere or ionosphere. A common feature of recent simulations is that they model the streamer inception from spherical Gaussian electron-ion patches. We here tackle the question: How do the streamer inception time and streamer properties depend on the initial geometry? Therefore, we consider prolate (“cigar”) and oblate (“pancake”) electron-ion patches aiming to understand the geometric influence on streamer inception speed, electric field evolution, branching time, and ohmic heating of streamers. We initiate patches of different geometry with fixed peak densities of 5·10¹¹ m⁻³ or with a fixed total electron number of 9.40·10¹² in ambient fields of 0.5 and 1.5 times the breakdown field and study the streamer evolution between 60 and 80 km altitude with a 2.5D cylindrical Monte Carlo particle code. We present the evolution of the electron density and of the electric field. In our simulations, the time for the electric field tips to develop into the regime where they can self sustain the discharge is shortest for streamers from prolate patches and longest for oblate patches. The branching time of negative fronts depends on the eccentricity and increases for oblate patches ranging from 5 μs to 8 μs. We observe ohmic heating with maximum temperature differences up to tens of K depending on the eccentricity and density of the initial patch influencing the efficiency of plasma reactions in streamer channels.

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The X-shooter GRB afterglow legacy sample (XS-GRB)

In this work we present spectra of all γ-ray burst (GRB) afterglows that have been promptly observed with the X-shooter spectrograph until 31/03/2017. In total, we have obtained spectroscopic observations of 103 individual GRBs observed within 48 hours of the GRB trigger. Redshifts have been measured for 97 per cent of these, covering a redshift range from 0.059 to 7.84. Based on a set of observational selection criteria that minimise biases with regards to intrinsic properties of the GRBs, the follow-up effort has been focused on producing a homogeneously selected sample of 93 afterglow spectra for GRBs discovered by the Swift satellite. We here provide a public release of all the reduced spectra, including continuum estimates and telluric absorption corrections. For completeness, we also provide reductions for the 18 late-time observations of the underlying host galaxies. We provide an assessment of the degree of completeness with respect to the parent GRB population, in terms of the X-ray properties of the bursts in the sample and find that the sample presented here is representative of the full Swift sample. We have constrained the fraction of dark bursts to be <28 per cent and confirm previous results that higher optical darkness is correlated with increased X-ray absorption. For the 42 bursts for which it is possible, we have provided a measurement of the neutral hydrogen column density, increasing the total number of published HI column density measurements by ∼33 per cent. This dataset provides a unique resource to study the ISM across cosmic time, from the local progenitor surroundings to the intervening Universe.

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Three dimensional polarimetric neutron tomography-beyond the phase-wrapping limit

Three dimensional polarimetric neutron tomography is an emerging method for non-destructive investigation of magnetic field strength and direction distribution in three dimensions. It utilises the Larmor precession of the neutron spin in the presence of an external magnetic field and has so far been restricted to the measurement of magnetic fields weak enough to keep the neutron precession below the phase-wrapping limit at 180º. Through the use of polychromatic time-of-flight information in combination with an iterative forward model reconstruction algorithm we have gone beyond this limit, thereby vastly broadening the potential of the technique. We present the reconstructed magnetic field of a measured current carrying solenoid as a proof-of-principle for this novel method, as well as successfully applying the method to a simulated data set of a sample consisting of multiple magnetic domains.

Time-dependent low-latitude core flow and geomagnetic field acceleration pulses

We present a new model of time-dependent flow at low latitudes in the Earth's core between 2000 and 2018 derived from magnetic field measurements made on board the Swarm and CHAMP satellites and at ground magnetic observatories. The model, called CoreFlo-LL.1, consists of a steady background flow without imposed symmetry plus a time-dependent flow that is dominated by geostrophic and quasi-geostrophic components but also allows weak departures from equatorial symmetry. Core flow mode amplitudes are determined at 4-month intervals by a robust least-squares fit to ground and satellite secular variation data. The l1 norm of the square root of geostrophic and inertial mode enstrophies, and the l2 norm of the flow acceleration, are minimized during the inversion procedure. We find that the equatorial region beneath the core–mantle boundary is a place of vigorous, localized, fluid motions; time-dependent flow focused at low latitudes close to the core surface is able to reproduce rapid field variations observed at non-polar latitudes at and above Earth's surface. Magnetic field acceleration pulses are produced by alternating bursts of non-zonal azimuthal flow acceleration in this region. Such bursts are prominent in the longitudinal sectors from 80–130°E and 60–100°W throughout the period studied, but are also evident under the equatorial Pacific from 130°E to 150°W after 2012. We find a distinctive interannual alternation in the sign of the non-zonal azimuthal flow acceleration at some locations involving a rapid crossover between
flow acceleration convergence and divergence. Such acceleration sign changes can occur within a year or less and, when
the structures involved are of large spatial extent, they can give rise to geomagnetic jerks at the Earth’s surface. For
example, in 2014, we find a change in the sign of the non-zonal azimuthal flow acceleration under the equatorial Pacific as
a region of flow acceleration divergence near 130°E changes to a region of flow acceleration convergence. This occurs at
a maximum in the amplitude of the time-varying azimuthal flow under the equatorial Pacific and corresponds to a
geomagnetic jerk at the Earth’s surface.

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Time-predictable synchronization support with a shared scratchpad memory
Multicore processors need to communicate when working on shared tasks. In classical systems, this is performed via
shared objects protected by locks, which are implemented with atomic operations on the main memory. However, access
to shared main memory is already a bottleneck for multicore processors. Furthermore, the access time to a shared
memory is often hard to predict and therefore problematic for real-time systems. This paper presents a shared on-chip
memory that is used for communication and supports atomic operations to implement locks. Access to the shared memory
is arbitrated with time division multiplexing, providing time-predictable access. The shared memory supports extended
time slots so that a processor can execute more than one memory operation atomically. This allows for the implementation
of locking and other synchronization primitives. We evaluate this shared scratchpad memory with synchronization support
on a 9-core version of the T-CREST multicore platform. Worst-case access latency to the shared scratchpad is 13 clock
cycles. Access to the atomic section under full contention, when every processor core wants access to acquire a lock, is
135 clock cycles.

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Version 2 of the EUMETSAT OSI SAF and ESA CCI sea-ice concentration climate data records
We introduce the OSI-450, the SICCI-25km and the SICCI-50km climate data records of gridded global sea-ice concentration. These three records are derived from passive microwave satellite data and offer three distinct advantages compared to existing records: first, all three records provide quantitative information on uncertainty and possibly applied filtering at every grid point and every time step. Second, they are based on dynamic tiepoints, which capture the time evolution of surface characteristics of the ice cover and accommodate potential calibration differences between satellite missions. Third, they are produced in the context of sustained services offering committed extension, documentation, traceability, and user support. The three records differ in the underlying satellite data (SMMR & SSM/I & SSMIS or AMSR-E & AMSR2), in the imaging frequency channels (37 GHz and either 6 or 19 GHz), in their horizontal resolution (25 or 50 km), and in the time period they cover. We introduce the underlying algorithms and provide an evaluation. We find that all three records compare well with independent estimates of sea-ice concentration both in regions with very high sea-ice concentration and in regions with very low sea-ice concentration. We hence trust that these records will prove helpful for a better understanding of the evolution of the Earth's sea-ice cover.

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