Stellar Astrophysics Centre 2020

SAC Virtual Morning Coffee at 10 o'clock is part of the 'new nomal' at SAC since March 2020.

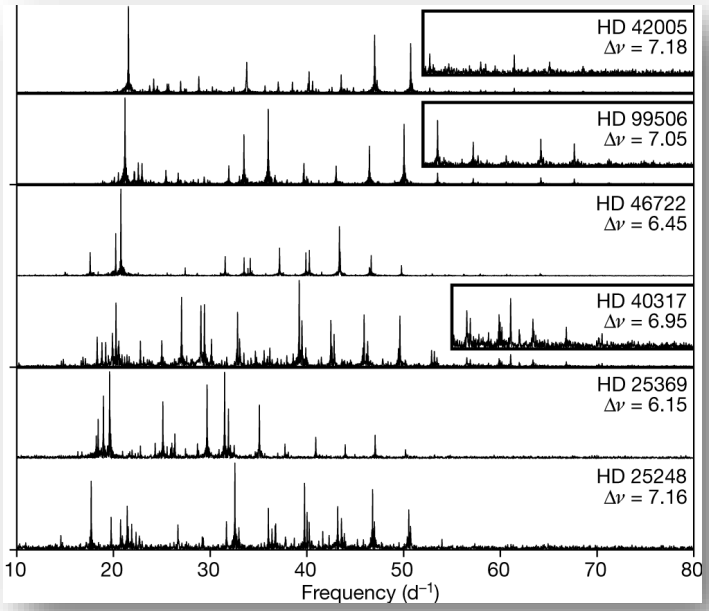
Scientific highlights of the year

For almost a decade, the Stellar Astrophysics Centre (SAC) at Aarhus University has been in a leading position within a broad range of research activities from stars and stellar environment to galactic archaeology, exoplanet properties and evolution as well as astrobiology. SAC is expected to maintain this position and the impact of the centre activities in the next decade both nationally and internationally. Most of the research activities and research infrastructures initiated, developed, upgraded or constructed by SAC will remain active and in operation for many years in the future.

The Corona Pandemic has of course affected SAC significantly and limited or made most scientific visits to Aarhus and abroad, travels, conferences impossible. The staff and students at the centre have continued our work within the boundaries and requirements of the authorities and the daily life at the centre continued in 2020 with virtual morning coffees, virtual talks and virtual workshops. Despite the Corona restrictions, the scientific productivity in terms of publications is very high and several key papers were published in 2020.

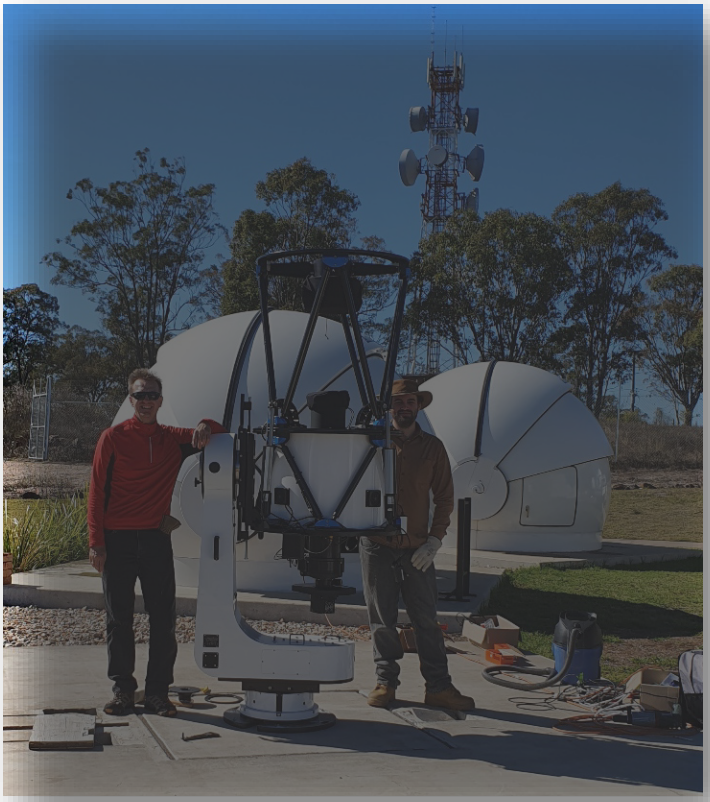
Using observations from the NASA TESS satellite, an international group of researchers with many SAC staff members (lead author is Tim Bedding from the SAC node at University of Sydney) has been studying 60 stars of the variable class named after the star delta Scuti. Until 2020, this class of stars has evaded precise determinations of their parameters because they oscillate in a very complex way making research on them difficult. One of the key tools used by SAC is asteroseismology where the oscillation frequencies for stars are used to study the structure and evolution of individual stars. This is done extensively and with high precision for the Sun and for stars similar to the Sun. Even though the delta Scuti stars in many ways behave like the Sun, these stars have not until now allowed detailed research because the oscillation frequencies do not show a structure that can be directly identified. For the first time, the new study found a regular pattern of oscillation frequencies in this type of stars. This now makes it possible to compare the observed frequencies to theoretical predictions, enabling us to learn more about the properties of these stars. This will have a significant impact on our understanding of how stars are working, and how they develop over time.

The figure shows some of the pulsation spectra for the stars discovered by use of the NASA TESS satellite to have remarkably regular patterns of peaks – to some extent similar to those we find in our own Sun.



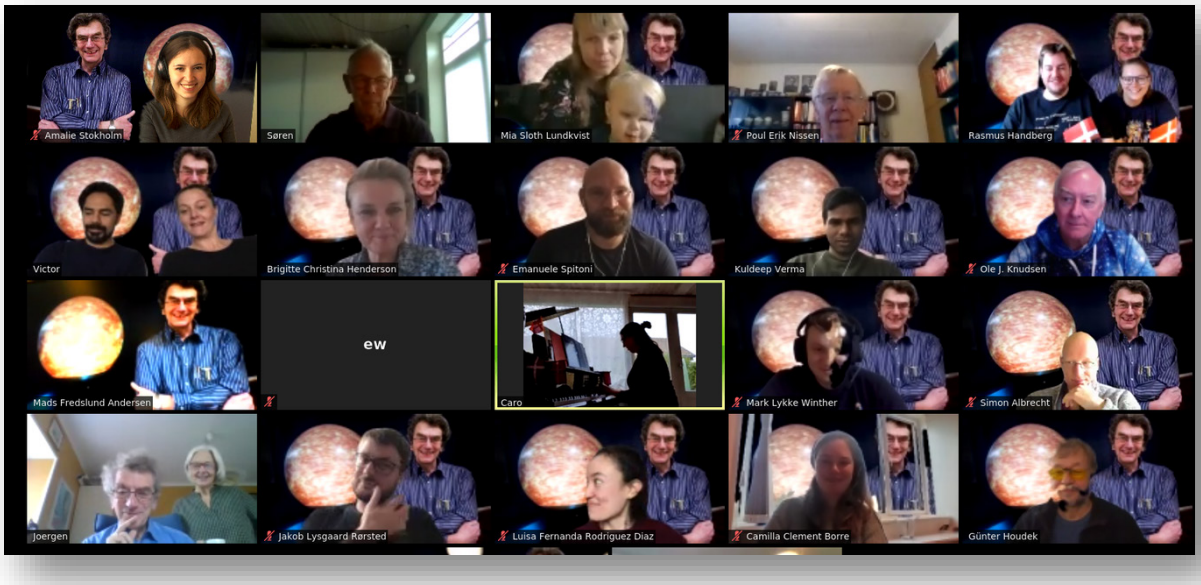
In another study using asteroseismology from TESS of a single star nu Indi, researchers from SAC were able to calculate the limits for an ancient galaxy merger between our Milky Way galaxy and dwarf galaxy Gaia-Enceladus less than 11.5 billion years ago. It is not new knowledge that over billions of years the Milky Way has swallowed other galaxies and this is part of many other studies at SAC. However, the new study is able to precisely measure the time of this event – thanks to the accuracy of asteroseismology.

A study by PhD student Anders Bo Justesen showed that for stars with companions (stars or exoplanets) the tilt between the stellar spin-axis and the orbital plane of a stellar or planetary companion is not aligned in the way that was expected. Until now, it has been the understanding that binary stars, where the two companions are relative close, are aligned, while double stars on wider orbits are often misaligned. The new study is based on spectroscopic data from the Hertzsprung SONG telescope on Tenerife, combined with astrometric data from ESA's Gaia satellite. In the new study, it was found that the previous understanding is not in agreement with the observed spin-orbit alignment. Double stars are equally aligned and misaligned at all orbital separations. This has important implications for the understanding of the formation and evolution of binary stars and exoplanet systems.



Frank Grundahl (left) next to the educational telescope owned by Aarhus University at the Mt Kent Observatory in Queensland, Australia. The two white domes in the background contain two telescopes that are part of the Stellar Observations Network Group (SONG). They are connected via a fibre to a high-dispersion spectrograph.

In 2020, SAC continued our work on several research facilities – including using the opportunities offered by the European Southern Observatory and ESA. At Mt Kent in Australia – part of the Stellar Observations Network Group (SONG) – we installed two new telescopes and a fibre-fed spectrograph as well as an educational telescope. This will be operational in 2021. We continue to use space missions for our studies of stars and exoplanets with SAC leading the planning of the asteroseismic component of the science programme for the extension of the TESS (NASA). SAC also continues to be involved in the planning of the future ESA PLATO space mission (expected launch in 2027). In 2020, Aarhus University took over the operation of the Nordic Optical Telescope on La Palma. The aim is to integrate part of the operations of the NOT and the SONG for the benefit of both facilities and ensure long-term operations. The Delphini-1 CubeSat – Aarhus University's first satellite – continued to operate throughout 2020 allowing students to take pictures from space.



On 6 October 2020 the SAC staff celebrated Jørgen Christensen-Dalsgaard's 70th birthday. Carolina is playing the piano (center) and with Jørgen being all over zoom!