Listening to other stars

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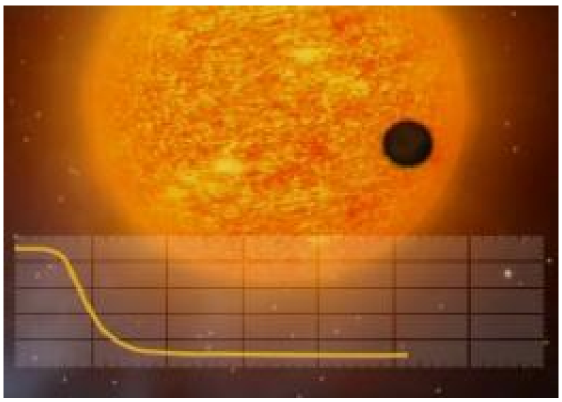

One method for detecting extrasolar planets, used on the CoRoT and Kepler missions, both dedicated also to the Asteroseismology observations, is calculating the extent to which a star's light dims when a planet transits in front of it.

When scientists realised that observing and analysing oscillations in the Sun could provide information about its interior, it was only a matter of time before Helioseismology was put to work on other stars.

The techniques used in Solar and Stellar Seismology are exactly the same, but applying them to other stars presents a greater challenge than the Sun because they are much farther away. This means that less light reaches us from them, making it more difficult to observe the slight changes in their oscillations that cause fluctuations in the brightness we can see. These changes are not easy to observe in the Sun either, although it helps that we can focus its light onto a point (like a star) and, because the Sun is close, we can obtain high resolution images of its sphere and see how waves spread from one zone to another.

William Chaplin, of the University of Birmingham spoke at the "4th International HELAS Conference" about how Stellar Seismology is demanding new instruments to observe these effects in stars, which need to be mounted on satellites to take continuous, high quality readings from above the Earth's atmosphere. Despite advances in technology, he said, ""it is still not possible to obtain a high resolution image of a star's disc. This means that we can only see waves that are propagated across the whole of the star (in contrast to what we can see on the Sun)".

Until recently the mass, radio signature and age of stars were determined using non-seismological techniques and the results were very inaccurate. Seismology is delivering great improvements. According to Chaplin, "it is now becoming possible to obtain images of the surface of large relatively near stars. In 20 or 30 years the technology will make it possible to observe these stars in as much detail as we can observe our Sun today. Whether this will happen during my working life is unclear."

Like all objects, stars can be classified in a thousand different ways, such as by temperature, volume, radio signature or age. Seismologists rank them according to their pulsations. Seismology can be used on many different kinds of stars: from stars smaller than our Sun (between 30% to 40% its size), which are colder and have weaker oscillations that are difficult to detect; to stars of a similar size and others that are larger and hotter than the Sun. The technique can also be used on stars that were once like the Sun but have now reached the end of their lifecycle and expanded to become red giants. These are much easier to observe as their oscillations are very pronounced.

The amount of information that we can obtain with seismology is determined by how easy or difficult it is to identify seismological signatures, or pulsations. All stars oscillate. The question is whether these oscillations can be detected. Space missions like CoRoT (*COnvection ROtation and planetary Transits*), Kepler and soon, perhaps, PLATO (*PLAnetary Transits and Oscillations of stars*) will be a big step forward for work on the vibration of stars.

CoRoT, a mission that looked for exoplanets, led to the discovery of seven planets of which one is the most Earth-like found to date in terms of its mass and radio signatures. Initial results from the mission showed that knowledge about star formation is vital to our understanding of planetary evolution because both of these processes occur together. They also led to the inclusion of a seismological option on Kepler, a mission that was initially designed to discover planets orbiting around other stars. The first results from Kepler were presented to the scientific community at the HELAS meeting in Lanzarote (Canary Islands).

Conny Aerts, researcher at the Catholic University of Leuven, says that "initial data from Kepler confirm that it is possible to understand the seismology of a star with planets, and from this to determine its age and composition". Aerts laments the fact that we still do not understand the relation between stars and planets very well, and asks whether the fact that the Solar System seems different to other planetary systems is due to a lack information or whether it really is unique.

CoRoT shows that there are planets out there, not just in the Solar System, and Kepler that the characteristics of stars with planets can be uncovered using seismological techniques. PLATO, a European Space Agency (ESA) mission that is part of the *Cosmic Vision* programme planned for 2015-2025, will provide further advances in work on star oscillations. PLATO will be the first mission to take a proper look at very bright stars within clouds of stars, which can also be observed using Earth telescopes like the forthcoming E-ELT (*European Extremely Large Telescope*). It is an important mission that will provide information about the way stars and planets are formed.

Aerts believes that the first results from Kepler prove that the aims of the PLATO mission are achievable. It has recently been confirmed that it is possible to determine the age of a star with a neighbouring planet the size of Jupiter accurately. PLATO aims to do exactly this, but for planets the size of the Earth. The mission will help us to understand where the Earth sits in the wide variety of planetary systems.

Networks of telescopes like GONG (*Global Oscillation Network Group*) have been continuously observing the Sun from Earth for some thirty years and they are now starting to be used on other stars. The planned SONG (*Stellar Observations Network Group*) network, which it is hoped will contain eight telescopes, will observe stars continuously for months at a time. The first telescope is already being built, and it is located in Tenerife.

Joergen Christensen-Dalsgaard works at the University of Aarhus and is member of KASC (*Kepler Astroseismic Science Consortium*), a group of three hundred scientists working to analyse Astroseismological data from the Kepler mission. He is clear that Earth and space missions need not be exclusive. Comparing the results from Kepler with potential future results from SONG, Christensen-Dalsgaard is certain that "many stars were observed by Kepler, but in less detail; with SONG there will be fewer stars but they will be seen in higher quality. The two programmes complement one another very well. The difference is that whilst Kepler looks at variations in a star's intensity, SONG will look at variations in its radial speed. It is very difficult to see oscillations if you observe intensity rather than speed." He is also enthusiastic about the results from Kepler. "We have waited decades for data like that coming from Kepler. I think that we are about to see a revolution in our understanding of Asteroseismology and the structure and evolution of stars."

Participants at the latest HELAS meeting are convinced that seismology of the Sun and other stars can make a major contribution to our understanding of the Universe. Rafael Garcia is a scientist at the CEA (*Commissariat à l'Énergie Atomique*) and he gives this very graphic explanation amidst the volcanic landscapes of Lanzarote, where solar and stellar seismologists are meeting: "The Sun, through seismology, is the foundation stone on which most of the models of star evolution are based. The advance in the theories of the stellar evolution will certainly affect our understanding of the galaxy evolution and will have a clear influence in other many fields of the modern Astrophysics. The Sun is the foundation stone of a huge building."

Source: Instituto de Astrofisica de Canarias