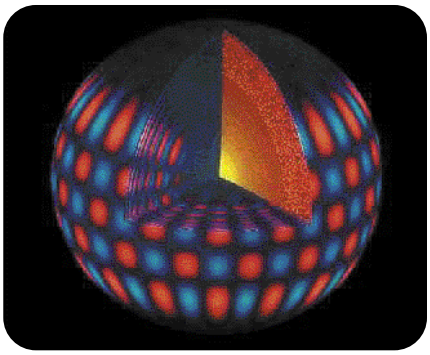


Leuven's Breakthrough in Asteroseismology

Drum 'n' bass in the cosmos

Karla Venken / Translation John Hymers

It is called xi Hydrae, and is 130 light-years removed from us. When a team of terrestrially based European astronomers successfully registered periodic oscillations on its upper surface, the giant star in Hydra became the first of its generation that humans have observed through music. Asteroseismology is a recent discipline of astronomers, but that science seems to be advancing at 'warp speed'.

What we know regarding the centre of the earth, we owe to the study of earthquakes and tremors on the earth's crust. Since the discovery of 'sunquakes' forty years ago, seismological research has also been progressively concerned with stars. Back then, astronomers first ascertained that the surface of the sun had oscillations with a specific frequency caused by turbulent waves from rising bubbles of hot gas just under the surface, causing it to move up and down in an apparently chaotic but rhythmic manner.

The cosmos is quiet because of an absence of a suitable medium for the transmission of sound waves; in our atmosphere the sunquakes would sound like a gigantic pipe organ. By analyzing solar music, astronomers have learned much about the internal structure of the sun, which, having seen five billion years, is half-way through its active life. Now that periodic oscillations have been verified in a completely different kind of star, asteroseismology has become the pre-eminent method for the study of stellar evolution, one of the specific research fields of Leuven's Institute of Astronomy. Professor Conny Aerts was the scientific director of these observations, which took place in concert with astronomers from the Observatoire de Genève, assisted by colleagues from the University of Aarhus (Denmark), whose models had predicted the oscillations.

Red-blue

Says Conny Aerts: "The Danish astronomers are specialized in the study of solar-type stars, and we study younger and more massive stars. In common with the observatory in Geneva, Leuven has expertise in long-term stellar observation. Our Mercator telescope in La Palma is a twin brother to their Euler telescope in Chile, and we have an agreement regarding the mutual use of both. Since xi Hydrae can only be seen in the southern hemisphere, the observations took place in Chile."

"You can listen to tremors on the earth's surface: seismologists analyze the movement of sound waves. Asteroseismologists watch with a telescope, and analyze the wavelengths of starlight by means of a spectrograph. You can compare this instrument with an ultra-precise prism, which breaks up light into its composite colours. Think of a rainbow: the rain drops form a rough prism that breaks up the sunlight. We observe stellar tremors because the movement of a star's surface causes light shifts in the red-blue spectrum of the starlight. This shift is due to the 'Doppler effect,' well known from the siren of an ambulance, which sounds increasingly higher as it approaches you and increasingly lower as it speeds away."

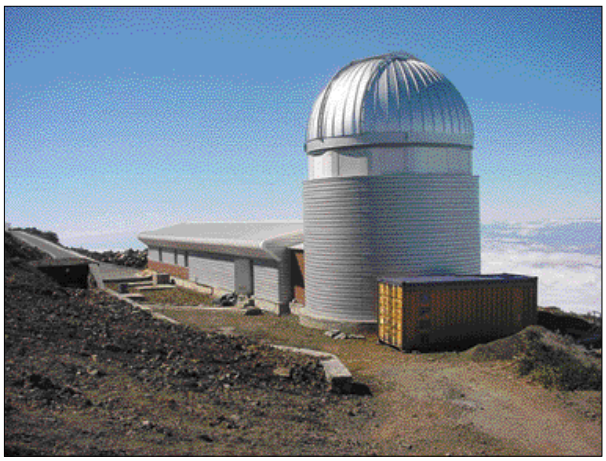
Patience!

"The difficulty is that stellar surfaces do not move up and down in the same manner. What we call non-radial oscillations you can best compare with what happens when you grasp an inflated balloon with both hands and press: the surface touching your fingers moves inward, and the surface between them bulges outward. For a star, that renders more or less a picture as represented in this photograph (cf. illustration): the sections of the surface that move below and thus toward the center of the star are red, and those describing an opposite movement are blue. We find various such non-radial oscillations in xi Hydrae. In order to unravel the combined effects of those oscillations, we must be measuring throughout the entire period of fluctuation, and for this reason we mounted a month-long observational campaign. Patience is beautiful virtue in our science! Just ask Thomas Maas, one of our doctoral students, who manned the telescope in Chile for 14 nights in order to carry out two spectrograph readings per hour of xi Hydrae. The second half of the observational period was the task of the Swiss astronomers. We have measured distinct oscillations, each with a period of about three hours, and can determine, given the amplitude velocity of two metres per second, that the surface of the star oscillates a few kilometres. To compare: the sun's oscillations reach speeds up to a few centimetres per second, and cause an average oscillation of a few metres every five minutes. To give you an idea of the unbelievable accuracy of the Swiss CORALIE spectrograph that we use: we have, in a manner of speaking, seen a balloon rise and fall at 7 km/h 130 light years from here, 90 minutes up, and 90 minutes down."

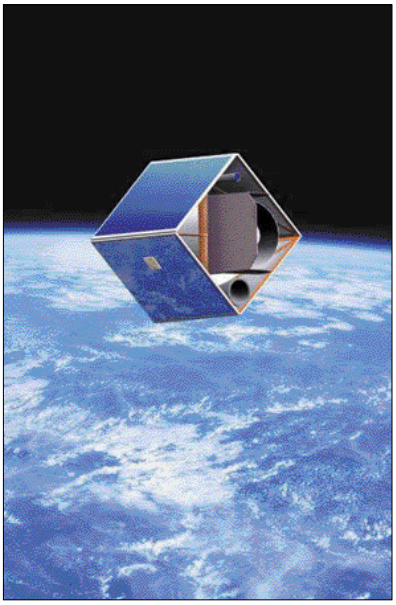
The picture above is a visual representation of a non-radial oscillation, more precisely a random picture of one modus.

Space Missions

"Even with perfect instruments and persistently optimal weather conditions, terrestrially based asteroseismological research is time consuming, labour intensive, and not very accurate. We can only measure on a few nights, which means that we must observe many hundreds of cycles before we can uncover the basic periods. Our rhythm of but one measurement per day constantly confronts us with 'false' periods. Above all, the earth's atmosphere causes the starlight to twinkle, which hinders the accuracy that we desire. The solution, naturally, is to do our measuring from space. Now that asteroseismology has met with such success, there are various asteroseismological space missions being planned. Our institute will participate in 3 new space missions: in 2005 with the Franco-European COROT satellite, with the Danish Satellite MONS, and in 2008 with the ESA's Eddington satellite. In our discipline, a research project in three years is like tomorrow. The coming decades will be the 'asteroseismological decades' for stellar astrophysics, and Leuven must play a role in this."



K.U.Leuven's Mercator telescope in La Palma (Spain), twin brother to the Euler telescope in Chile with which xi Hydrae was observed.



Impressions of the Danish Satellite MONS, one of the three asteroseismological space missions in which Leuven will participate in the next few years.

The sound of xi Hydrae

If you wish to know how xi Hydrae sounds, you can find a 15-second sound clip linked to the web pages of the European Southern Observatory. Our ears are not sensitive enough for the ultra-low tones of xi Hydrae, and therefore the measured frequencies have been multiplied by a factor of a million for the clip. If your computer has weak speakers, then you will hear a cacophonous tinny drum roll. But with good speakers, you will get a sample of heavy drum 'n bass on a bed of tribal cosmic heartbeats. Xi Hydrae is close to death. Having existed for 250 million years, it 'only' has 70 million years before it extinguishes itself as a white dwarf.

www.eso.org/outreach/press-rel/pr-2002/pr-10-02.html