THE SONG OF THE SUN

Signals that our Star's Activity is Slowing Down

The University of Birmingham has been gathering helioseismological data on the Sun since 1985, a period covering three of our star's 11-year activity cycles. These cycles refer to periods where the Sun's generation of energetic particles wax and wane as the interaction between its magnetic field and outer physical layers fluctuate. Currently, we're transitioning into a solar minimum, expected to be reached in either 2019 or 2020, a period of low magnetic activity for the Sun, when fewer sunspots and solar flares are generated.

The waves that reverberate back and forth throughout the Sun are generated by turbulence in the gases roiling in our star's convection zone, an upper layer lying just under the surface's photosphere shell. Much like how seismic waves rebound back and forth through the Earth's interior, the Sun also traps these waves within itself, but research into this resonance is suggesting that its activity may continue a 23-year long trend of relative quiet. Professor **Yvonne Elsworth**, of the School of Physics and Astronomy at the University of Birmingham explains:

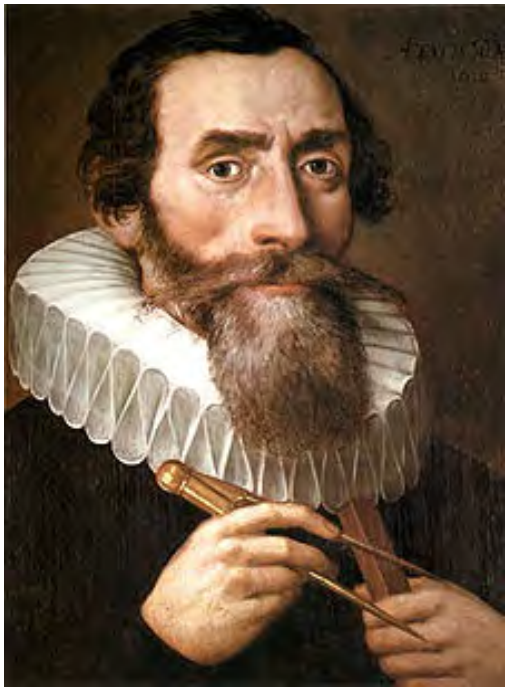
"The Sun could be compared to a musical instrument, with its notes a very low frequency – thousands of times lower than middle C.

"Studying these waves, using a technique called helioseismology, enables us to find out what's going on throughout the Sun's interior. The last solar minimum, having occurred in 2010, was unusually quiet, including a period where the Sun's surface was nearly devoid of sunspots for almost two years -- a phenomenon that hadn't been seen since 1913. And despite predictions that the period's unusual quiet would result in a sudden explosion of activity when the minimum ended, the Sun still took several years to get back into its active cycle. Even then, the Sun's acoustic properties have as such failed to re-set to their pre-1994 state.

"Recent activity maxima have actually been rather quiet and the last cycle had a long, extended minimum. It will be interesting to see if the minimum of this current cycle is extended in the manner of the previous one or if it will soon be back to the conditions of the past. However, if it is a normal minimum it will also be interesting to ask why the previous one was unusual."

Elsworth and her team are unsure as to what these changes mean for our Sun, **but when they apply their data to radical transitions recorded in other stars, this strange behaviour "lends weight to the speculation that a fundamental change in the nature of the solar dynamo may be in progress."**

Comparing our Solar System, and the harmony found within in it, with a musical instrument, is a tradition going back a long way. The Greek philosopher **Pythagoras** (570 BC to 495 BC) is frequently credited with originating the concept. His celestial spheres were the fundamental entities of celestial mechanics, studied by **Eudoxus**, adopted by **Aristotle** and developed by **Ptolemy**, **Copernicus** and others. In this celestial model the stars and planets are carried around by being embedded in rotating spheres made of an ethereal transparent fifth element (quintessence), like jewels set in orbs. The spheres were most commonly arranged outwards from the centre in this order: the sphere of the Moon, the sphere of Mercury, the sphere of Venus, the sphere of the Sun, the sphere of Mars, the sphere of Jupiter, the sphere of Saturn, and then the starry firmament. **At that time, all the heavenly bodies were thought to revolve around Earth in their proper spheres, related to each other by the whole-number ratios of pure musical intervals, creating musical harmony**. Christian and Muslim philosophers modified Ptolemy's system to include an unmoved outermost region, which was the dwelling place of God. The outermost moving sphere, which moved with the daily motion affecting all subordinate spheres, was moved by a fixed unmoved mover, the Prime Mover, who was identified with God. Each of the lower spheres was moved by a subordinate spiritual mover (a replacement for Aristotle's multiple divine movers), called an intelligence. Around the turn of the millennium, the Arabian astronomer and polymath **Ibn al-Haytham (Alhacen)** presented a development of Ptolemy's geocentric epicyclic models in terms of nested spheres. In his Book of Optics Ibn al-Haytham considers that the celestial spheres may not consist of solid matter and this reflects an independent development of the concept.



Johannes Kepler (1571 AD to 1630 AD) used the concept of the music of the spheres in his Harmonice Mundi, Harmony of the Worlds in 1619. Kepler was convinced "that the geometrical things have provided the Creator with the model for decorating the whole world." In Harmony, he attempted to explain the proportions of the natural world - particularly the astronomical and astrological aspects - in terms of music. According to Johannes Kepler, the connection between geometry, cosmology, astrology, harmonics, and music is through the music of the spheres.

In Johannes Kepler's celestial physics the spheres were regarded as the purely geometrical spatial regions containing each planetary orbit rather than physical bodies as rotating orbs as in preceding Aristotelian celestial physics. The eccentricity of each planet's elliptical orbit and its major and minor axes thereby defined the lengths of the radii of the inner and outer limits of its celestial sphere and thus its thickness. In Kepler's celestial mechanics the ultimate causal focus shifted on the one hand to the Platonic regular polyhedra within which Kepler held they were embedded and on the other hand to the rotating Sun as the central inner driver of planetary motion, itself rotated by its own motor soul. However, an immobile stellar sphere was a lasting remnant of physical celestial spheres, even in Kepler's cosmology.

But then, solid physical spheres still featured in both **Galileo's** and **Newton's** early celestial mechanics, with Galileo initially considering the planets to be rolling around the upper surfaces of fixed perfectly smooth spheres driven by their own impetus and gravity, and with Newton calculating the centrifugal pressure that would be exerted by the Moon on the lower concave surface of the lunar orb in his 1660s analysis of lunar gravity. Thus for a long time Galileo fiercely resisted the Tychonic theory that comets are superlunary, because it destroyed his spherist celestial mechanics by knocking away the counter-gravitational supporting surfaces of the rolling planets, and he was unable to explain circular orbits as closed curve projectiles driven by a centrifugal impetus and centripetal gravity.

Today the Kepler space telescope measures the sizes and ages of stars five times better than any other means, when it "listens" to the sounds they make, called "astro seismology". The technique measures minuscule variations in a star's brightness that occur as soundwaves bounce within it. **Using resonances, we can literally build up a picture of what the inside of a star looks (sounds) like**.

An example of the persistence of the celestial harmony idea can be found in **Johann Wolfgang von Goethe's** Prologue in Heaven of the Faust tragic play, which starts with the poem:

Die Sonne tönt nach alter Weise
Im Brudersphären Wettgesang,
Und ihre vorgeschriebne Reise
Vollendet sie mit Donnergang.

Roughly translated this says: As the Sun goes thundering on its prescribed path in the sky each day, you can, if you listen carefully, also hear the sound of it competing in a harmonious song contest with all the other heavenly objects in a celestial concert.

We look forward to "hear" how Elsworth and her team apply their data to the nature of the solar dynamo. AK, with Wikipedia & Richard Giles Notes