Feature Article

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Thomas' work has taken him across the world, from Denmark to Spain, Chile, Hawaii, and back to Europe. His is currently working as an astronomer in ESO, where he is doing his own research and providing support to the users of ESO's telescopes.

Magnetic fields within stars and extrasolar planets may seem like two totally separate topics, but as is often the case with astronomy, there are many surprising links. Join astronomer Thomas Dall as he explains how these two subjects help with his research.

From fusion energy to life: magnetic fields, exoplanets, and the Earth

"What is it good for?" A common question. What can this research be used for? Unlike, for example biochemistry, astronomy has a more immediate public appeal, but it is also less obvious what it can be used for.

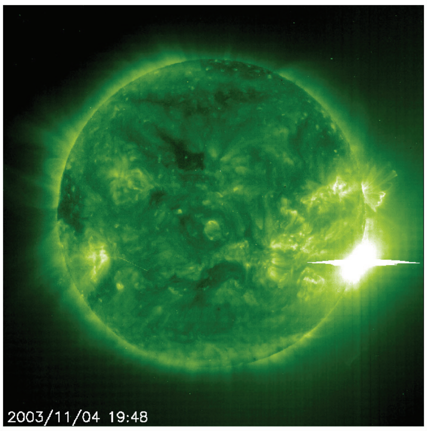
There are many applications of astronomy in our daily lives that are not usually recognised as such. Global Positioning Satellite (GPS) systems, the internet, smart materials, etc. These all owe part of their development to astronomy. But I want to talk a little about other reasons why astronomy is "profitable".

I study magnetic fields in stars. Why stars and why not in a laboratory? Because stars are natural laboratories where Nature creates conditions and effects that are impossible to study in the lab. Why magnetic fields? There are two reasons.

First, magnetic fields influences the evolution of a star and the environment around it, which is of vital importance to the planets around the star. Planets like the Earth. Changes in the solar magnetic field can have colossal consequences for climate and life on Earth. Thus, the study of magnetic fields is important for our understanding of our own destiny, of life itself.

Astronomy and space science have many direct applications for our lives here on Earth. Communication and weather satellites need to be launched into orbit, to give just one example.
Image credit: NASA/ESA.

Second, magnetic fields are believed to be necessary to control nuclear fusion, by which stars create energy. The taming of fusion on Earth would mean a practically endless and cheap source of clean energy. Imagine what such an energy source would mean to the world… no more fighting over oil and gas since the fuel for fusion energy is water!



The looped structures in this false-colour image of our Sun are caused by magnetic fields.
Image credit: NASA/ESA.

Our destiny. Life itself. Clean energy. This research is ultimately about the future of mankind. A future that we can shape and influence in an informed way. If we want to.

"How to study magnetic fields?"

Stars are mostly like the Sun: spheres of very hot gas where nuclear reactions in the interior provides energy which are radiated as light and heat. But there's more.

Like the Earth, the Sun has a magnetic field, but it is quite a different one. Whereas the magnetic field of the Earth changes only slowly with time, the much more violent movements in the solar interior makes for a constantly changing solar field. The field on the Sun originates in the zone just below the surface where energy starts to be transferred by radiation from being largely carried by convection (the "boiling pot" pattern visible on the Solar surface). Particularly concentrated areas of magnetic fields can penetrate the surface and cause sunspots. These spots are still very hot, but they are cool compared to the surroundings so they appear darker.

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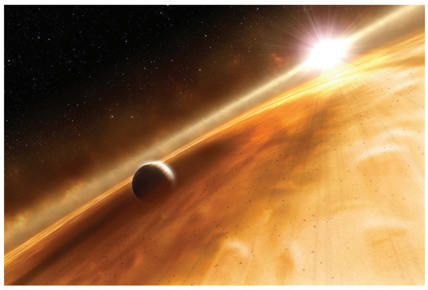

Knowing about the magnetic fields of stars can help astronomers detect and confirm new planets far from our own.
Image credit: ESA, NASA and L. Calçada (ESO).

The magnetic field can in some cases be measured directly, but for stars other than the Sun we have mostly relied on indirect measurements of spectral lines and particular line emissions that are associated with magnetic fields. To cover our ignorance of the fields themselves, we often refer to "magnetic activity" - which means that we see the indirect evidence of magnetic fields but not the fields themselves.

"What has this to do with planets?"

One of the most exciting developments over the past 10 years or so is the continuing discoveries of more and more extra-solar planets. The first planets found were gas giants even far more massive than the largest planet in the Solar system, Jupiter. But gradually, as observing techniques improved, lighter and lighter planets have been discovered and just within the last year or so have we entered the realm of true Earth-like planet discoveries. This means that the planets being discovered now are just slightly larger than Earth, have orbits that are not too different, and for some of them this might even mean that liquid water can exist on the surface and thus that the possibility of life is present.

The prime technique to detect planets is by measuring the slight velocity shifts of the host star caused by the gravitational pull of the planet. This involves measuring the position of spectral lines to very high accuracy. Unfortunately for planet hunters, the spectral lines of most stars are not stable in their own right. They are affected by convective motions in the stellar atmosphere, but most notably they are affected by magnetic activity. Or more precisely, by stellar spots.

When a spot appears on the surface of the star, it will dim the light coming from that area, which in turn will have an effect on the measured position of spectral lines. As the spot rotates across the stellar surface, the position of the line changes and it so happens to mimic quite accurately the change in line position that an orbiting planet would produce.

Fortunately, there are ways to tell a spot from a planet, but this involves long-term monitoring of the star (spots form and dissolve - planets do not) and detailed looks at the shape of the spectral line profiles (spots change the shape of the line slightly - planets are not affecting the stellar atmosphere at all). So what this means in practice is that astronomers must wait until they have long enough time coverage and have made enough tests before they announce the discovery of yet another extra-solar planet.

"What will the future bring?"

More and more planets will be discovered and eventually we will find planets that in their mass and orbit look exactly like the Earth. But these are all indirect measures. To be able to actually study these planets directly we need the next generation of super-sized telescopes. One of these is the European Extremely Large Telescope (E-ELT). This giant telescope will have a number of ultra-stable spectrographs that will allow us to directly study the properties of the planets and magnetic fields of our neighbouring stars. The lessons to be learned from this on a fundamental level cannot be overstated.

Not only could this endeavour bring us new physics, it may bring us a whole new mind set. These new discovery machines might open the door to a new understanding of our place in the cosmos and the ultimate fate of our own planet and our own civilisation. It may not be long before we know of other Earths; some still young, some mature, others doomed in orbit around dying stars. We might soon know of life outside the Earth. Truly, the story of life has just begun.

The term "One World" could come to mean even more than it does today.

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