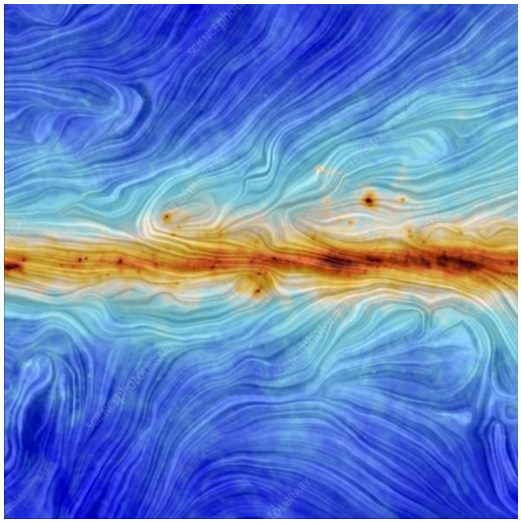
COSMIC MAGNETISM



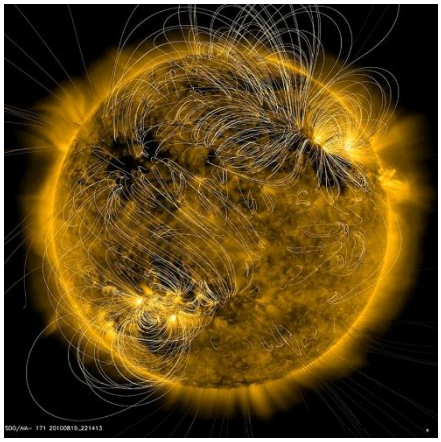
Every week the Observatory has a science meeting, where after all the interesting admin updates are announced, progress in the various science activities are reported and discussed. One of the main projects in progress at the moment is an international programme to map the magnetic fields of our galaxy, the Milky Way.

The Milky Way's magnetic field

Most of us don't think much about the incredibly weak magnetic fields pervading our and other galaxies. It is only recently that it has become possible to map them. We cannot see the magnetic fields directly, but we can see the effects they have on the cosmic radio emissions passing through them. This has enabled researchers to make maps of those magnetic fields. The images show an amazing level of fine detail. In some of them, the magnetic fields and the material trapped in them resemble a fine, piled carpet, and in others, like long, carefully brushed hair.

A big cosmic cloud of just gas and dust has only one force acting on it, gravity. This will tend to pull the gas together into lumps. It won't produce any other kinds of fine structure. Because there are motions and flows of material in the cloud, these motions get concentrated in those collapsing lumps, leading to them becoming rotating discs. However, when we add the magnetic fields, things become more complicated, and more interesting.

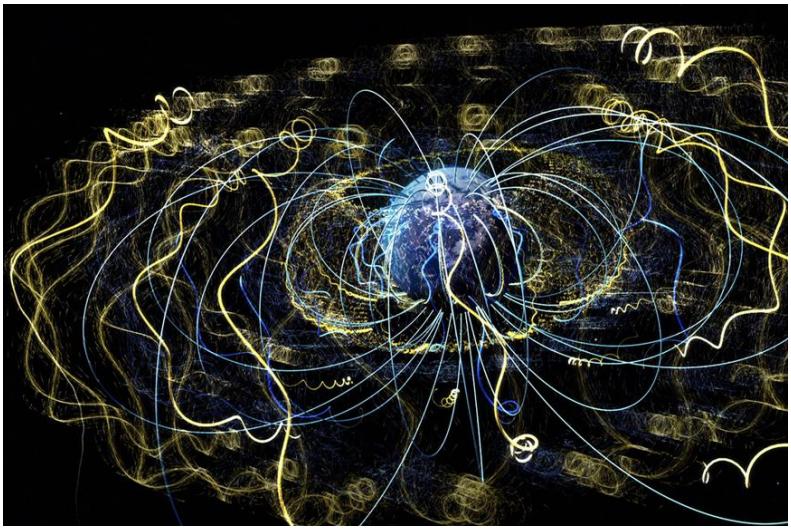
Magnetic fields with material trapped in them behave rather like rubber, forming loops, tubes and sheets. They can be stretched, twisted or compressed. Depending on how they are arranged, they can allow structures to combine or keep them as separate objects. Those fibres and other fine structures we see in the cosmic clouds could not exist without embedded magnetic fields. In addition, depending on how they are arranged, magnetic fields can either inhibit or encourage the collapse of clouds to form new stars and planets. In addition, those collapsing clouds take their magnetic fields with them, embedding them into those new stars and planets.



Stars are often described as balls of hot gas with nuclear fusion reactors in the middle. However, images of the Sun show it to be a lot more than that. It has an identifiable surface layer, loaded with fine details, with sunspots and with great loops and streamers extending into space. These structures exist because of the magnetic fields.

When the Sun formed it inherited magnetic fields from its birth clouds. With the flows of hot materials in the interior of the newly born star, they formed a dynamo, which generated electric currents, which in turn generated new and stronger magnetic fields. Because these magnetic structures can be bent, twisted and compressed, they can store energy, just like stretched elastic bands, providing the energy for solar storms and flares.

The situation is similar for earth-like planets. In this case the dynamos are formed by the interaction of the captured magnetic fields with the flow of hot, molten iron in their cores. The dynamo running inside the Earth gives rise to a magnetic envelope around the planet, keeping the solar wind away, stopping it from scrubbing away our atmosphere.



Gradually, the cores of planets cool off and solidify. At this point the dynamos shut down, the electric currents cease and the magnetic field protecting the planet vanishes. This has been the fate of Mars. It is smaller than our world, cooled off faster and lost its magnetic field long ago, allowing the solar wind to remove most of its atmosphere.

It might have seemed that cosmic magnetic fields would be something of academic interest only. That is definitely not the case. Without them, we and the other living things sharing this planet would not be here.

Ken Tapping, 3rd December, 2024

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