Weir in space and dimmed sun creates 200-million-mile-long lab bench for turbulence research

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This is Professor Sandra Chapman from the University of Warwick. Credit: Professor Sandra Chapman

Physicists working in space plasmas have made clever use of the Ulysses spacecraft and the solar minimum to create a massive virtual lab bench to provide a unique test for the science underlying turbulent flows.

Researchers have an ideal mathematical model of turbulence in fluids (ideal because the model is of an infinitely large flow). They also have been able to measure how such turbulence builds over time by measuring how that turbulent flow of material fluctuates as it crosses or hits a boundary wall in small confined boxes within a lab. However, until now, researchers have not had access to a means of carrying out much more large scale experiments to test the ideal turbulence.

However University of Warwick plasma astrophysicists Professor

Sandra Chapman and Dr Ruth Nicol have found a particularly elegant solution to fill that experimental gap employing Ulysses spacecraft and two solar minimum to map the turbulence in the energies of the turbulence in the solar wind - a magnetohydrodynamic (MHD) flow.

Normally the 'noise' from violent eruptions on the sun would disturb the turbulent flow. Ulysses' controllers had cleverly contrived for the spacecraft to pass over each of the Sun's poles during two different solar minima making it possible not only to gather data but also to be able to compare two different energy levels in a turbulent flow. The level of turbulence is down by a factor of 2 in the most recent solar minimum compared with the previous one.

The spacecraft was able to record the state of the turbulent flows flowing past it at 750kms a second at a distance of up to 2.83 Astronomical units from the Sun. This in effect allowed the spacecraft to record the developing turbulence as a flowed up to the satellite's position which then became like a weir in space creating a virtual confined laboratory box to test the development of flows over a time - but a confined box which was over 200 million miles in size.

The spacecraft orbited over the Sun's poles at two very different solar minima with clear differences in energy levels that could have created two very different forms of developing turbulence in the Solar Wind. However the researchers were surprised to find clear similarities in the measurements of the two "different" solar winds at each of the solar minima despite the fact that there was a significant difference in the energy levels of the solar wind during the two different solar minima (17% lower plasma density and 15% lower magnetic field in the later solar minimum)

They found that in all the polar passes of the spacecraft the evolution of turbulence in the Solar wind was governed by the same generalised scaling function no matter how much energy was in the system. This suggest that there is a universal basic property governing the evolution of magnetohydrodynamic turbulence over finite distances - in this case a finite distance of over 200 million miles.

Professor Sandra Chapman also said :

"These results are not just an interesting piece of astrophysics or turbulence research as the work has been produced in the University of Warwick's 'Centre for Fusion, Space and Astrophysics' and the results have also immediately come to the attention of our colleagues interested in how turbulence evolves in confined plasmas on earth - which will someday generate fusion energy. Turbulence is a big problem for colleagues interested in keeping the hot plasma confined long enough for burning to take place to generate fusion power and this may give those colleagues some valuable new insights."

More information: The research entitled 'Generalized similarity in finite range solar wind magnetohydrodynamic turbulence' has just been published in *Physical Review Letters*.

Source: University of Warwick (news : web)

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