Energy simulation may explain turbulence mystery

February 26 2009

(PhysOrg.com) -- A new 3D model linking magnetic fields to the transfer of energy in space might help solve a physics mystery first observed in the solar wind 15 years ago.

Scientists at The University of Alabama in Huntsville and Ruhr University in Bochum, Germany, developed the simulation while studying turbulence and energy transfer in the plasma carried away from the sun in the solar wind.

"We were attempting to understand the spacecraft observations that have seen this kind of turbulence," said Dr. Dastgeer Shaikh, an assistant professor in the Physics Department at UAHuntsville. "This was seen first by the Wind spacecraft launched in 1994, but has also been seen by other satellite instruments since then."

What Wind and the other spacecraft saw was particles in relatively small-scale solar wind eddies getting "hotter" than theories predicted they should get.

A theory published in 1941 by mathematician Andrey Kolmogorov established a generally accepted relationship between the size of eddies and the amount of energy released or dissipated: The smaller an eddy gets the more it interacts with its surroundings, so the greater the energy loss. This "lost" energy heats plasma in the solar wind.

The Kolmogorov law set the ratio between size and energy at 5/3: In a

dynamic fluid, the amount of energy released should increase by a factor of five when the size of the eddy shrinks by two-thirds.

Except, apparently, in the solar wind and other regions influenced by magnetic fields. The Wind spacecraft and others found that in the solar wind's smaller eddies the link between size and energy jumps to 7/3, a 40 percent increase in the efficiency of energy transfer between larger and smaller plasma eddies in the turbulent solar wind.

The computer model developed by Shaikh and Dr. P.K. Shukla in Germany tries to explains the sudden increase by looking at the interaction between turbulent magnetic fields and the outward flowing currents of plasma ions and electrons.

"The magnetic field is responsible for energy cascades," said Shaikh. Constrained by magnetic fields, the small eddies serve to "damp" the wave energy in them.

"This is the same kind of thing that happens in a microwave oven," Shaikh said. "Microwaves are damped inside the food and release the energy that makes the food hot."

If small eddies in the solar wind are more efficient than expected at transferring energy, that might help explain the hot particles discovered by instruments aboard Wind and other spacecraft.

Results of this research were published earlier this month in the on-line edition of "*Physical Review Letters*."

Provided by University of Alabama in Huntsville