Scientists explain mystery of observed turbulent density fluctuations in interplanetary space

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(PhysOrg.com) -- Scientists at The University of Alabama in Huntsville have developed a three-dimensional simulation model to understand behavior of interplanetary charged particles in space.

Physics professors Dastgeer Shaikh and Gary Zank of the university's Center for Space Plasma and Aeronomic Research and Department of Physics said the model explains how density of the interplanetary particles varies in time and space. Remarkably, the distribution of scale sizes of the density fluctuations is observed to satisfy a universal law called the Kolmogorov-spectrum.

The researchers noted that interplanetary space surrounding Earth is filled up by randomly moving charged and uncharged particles. These particles originate essentially from stars like our Sun or other nearby stars and are accelerated through interplanetary space. These are real "micro-probes" that tell us about distance, composition and many important aspects of the distant cosmological objects such as neighboring stars, galaxies and massive astrophysical clouds.

"From the behavior of these particles in space, it is possible to know the extent of the physical universe," they explained. "We provide a simpler explanation of why should particle density follow a Kolmogorov-spectrum. The interplanetary space is like water or air surrounding us. The charged particles are tied to the mass-less rope of magnetic field

lines and move around in water in a random manner. Something similar to "cream in a cup of coffee" or particles of 'baby talcum powder' spread on the surface of stirred water that convects the particles of powder along with the water flow. We find that these particles follow a Kolmogorov-spectrum. We are trying to understand their motion statistically."

NASA's Voyager 2 spacecraft, cruising in the outer space for nearly 30 years, has tracked down the interplanetary particle density from our Sun to a distance up to 100 times the distance between the Sun and Earth. That is 93.7 million miles multiplied by 100. "It was found that the particle density varies with distance by a Kolmogorov-spectrum. But one of the major hurdles in understanding this spectrum is interplanetary turbulence that makes the particle's trajectory random in space and time," the scientists said.

The original theoretical effort behind this model was laid down in early 1990s by Dr. Zank, who had put forward "a truly amazing hypothesis" that related the density to velocity of these turbulent particles, according to Dr. Shaikh. "It took us nearly 20 years to computationally realize the truth behind Zank's model. We run our higher resolution computational model on San Diego supercomputer (256 processors) to arrive at this conclusion. Our model is also consistent with Voyager's observations."

Drs. Zank and Shaikh said it's important to know correct statistical behavior of the interplanetary particle density. "Some of the techniques (like angular broadening) are based on density variations to measure the distance of stellar objects from Earth. Precise measurement of density field is critical to determine exact location, age, and composition of the stellar bodies," they said.

Their research will appear in the November issue of the *Royal Astronomical Society's* journal.

More information: "The turbulent density spectrum in the solar wind plasma", ref. MN-09-0751-MJ.R4, has been accepted for publication in Monthly Notices of the Royal Astronomical Society Main Journal.

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