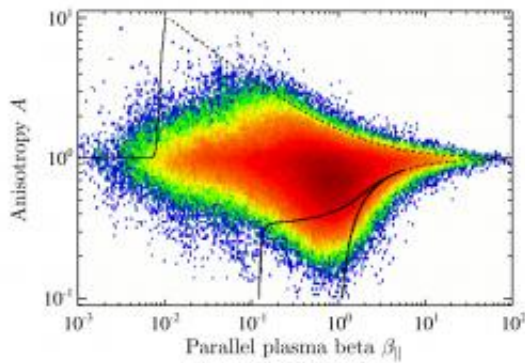


Why solar wind is rhombic-shaped?

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The plasma beta represents the ratio of kinetic to magnetic pressure in the cosmic plasma. The anisotropy is the ratio of the perpendicular and parallel temperatures to the magnetic field lines. The number of measured values is shown in colour (red corresponds to many values, blue to few values). Why the measurements take on the characteristic rhombic shape is explained by a new model by Bochum's physicists. Source: Physical Review Letters

Why the temperatures in the solar wind are almost the same in certain directions, and why different energy densities are practically identical, was until now not clear.

With a new approach to calculating instability criteria for plasmas, Bochum researchers lead by Prof. Dr. Reinhard Schlickeiser (Chair for [Theoretical Physics](#) IV) have solved both problems at once. They were the first to incorporate the effects of collisions of the solar wind particles in their model. This explains experimental data significantly better than

previous calculations and can also be transferred to cosmic plasmas outside our solar system. The scientists report on their findings in [Physical Review Letters](#).

Temperatures and pressures in the cosmic plasma

The solar wind consists of charged particles and is permeated by a magnetic field. In the analysis of this plasma, researchers investigate two types of pressure: the magnetic pressure describes the tendency of the [magnetic field lines](#) to repel each other, the kinetic pressure results from the momentum of the particles. The ratio of kinetic to magnetic pressure is called plasma beta and is a measure of whether more energy per volume is stored in magnetic fields or in particle motion. In many cosmic sources, the plasma beta is around the value one, which is the same as energy equipartition. Moreover, in cosmic plasmas near temperature isotropy prevails, i.e. the temperature parallel and perpendicular to the magnetic field lines of the plasma is the same.

Explaining satellite data

For over a decade, the instruments of the near-earth WIND satellite have gathered various solar wind data. When the plasma beta measured is plotted against the temperature anisotropy (the ratio of the perpendicular to the parallel temperature), the data points form a rhombic area around the value one. "If the values move out of the rhombic configuration, the plasma is unstable and the temperature anisotropy and the plasma beta quickly return to the stable region within the rhombus" says Prof. Schlickeiser. However, a specific, detailed explanation of this rhombic shape has, until now, been lacking, especially for low plasma beta.

Collisions in the solar wind

In previous models it was assumed that, due to the low density, the solar wind particles do not directly collide, but only interact via electromagnetic fields. "Such assumptions are, however, no longer justified for small plasma beta, since the damping due to particle collisions needs to be taken into account" explains Dipl.-Phys. Michal Michno. Prof. Schlickeiser's group included this additional damping in their model, which led to new rhombic thresholds i.e. new stability conditions. The Bochum model explains the solar wind data measured significantly better than previous theories.

Universally valid solution

The new model can be applied to other dilute cosmic plasmas which have densities, temperatures and [magnetic field](#) strengths similar to the solar wind. Even if the diagram of temperature [anisotropy](#) and plasma beta does not have exactly the rhombic shape that the researchers found for the [solar wind](#), the newly discovered mechanism predicts that the values are always close to one. In this way, the theory also makes an important contribution to the explanation of the energy equipartition in cosmic plasmas outside of our solar system.

More information: R. Schlickeiser, M. J. Michno, D. Ibscher, M. Lazar, T. Skoda (2011): Modified temperature-anisotropy instability thresholds in the solar wind, Physical Review Letters, 107, 201102, [doi: 10.1103/PhysRevLett.107.201102](https://doi.org/10.1103/PhysRevLett.107.201102)

Provided by Ruhr-University Bochum

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