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TURBULENCE TRANSPORT THROUGHOUT THE HELIOSPHERE

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Overview

- Turbulence is a universal phenomenon describing random departures of a system from a mean state.
- The transport of turbulence describes how energy in the fluctuations is moved from/to and influences different parts of a fluid system.
- The solar wind is inhomogeneous and possesses regions that are super- and sub-Alfvenic.
- Zank et al. 2012 developed a model to describe the transport of turbulent energy and related quantities throughout the heliosphere.

We present the first solutions to the complicated Zank et al. 2012 turbulence transport model equations and compare the transport model with observations from 0.29 - ~90 AU.

Inner Heliosphere

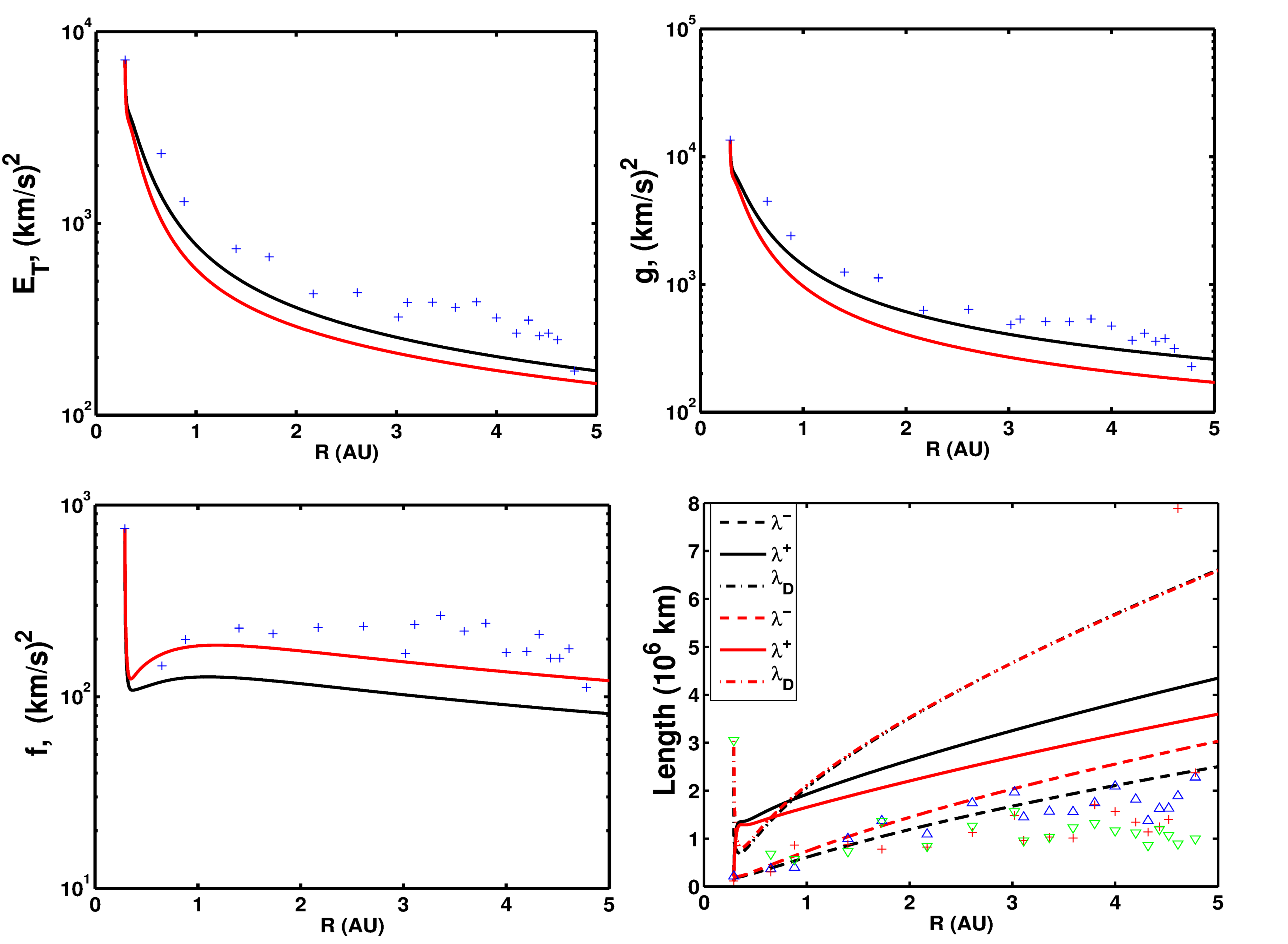

Fig: Comparison between the theoretical and observational results of the total turbulent energy, the energy corresponding to the forward propagating modes, the correlation lengths, and the energy corresponding to backward propagating modes as a function of heliocentric distance in a clockwise direction from top to bottom. The scattered diagrams are the corresponding observed values. Upward triangles and lambda^- correspond to the forward propagating modes, plus symbols and lambda^+ the backward propagating modes, and down-facing triangles and lambda^D the residual energy.The red curve denotes solutions without the Alfven velocity, and the black curve with the Alfven velocity.

Outer Heliosphere

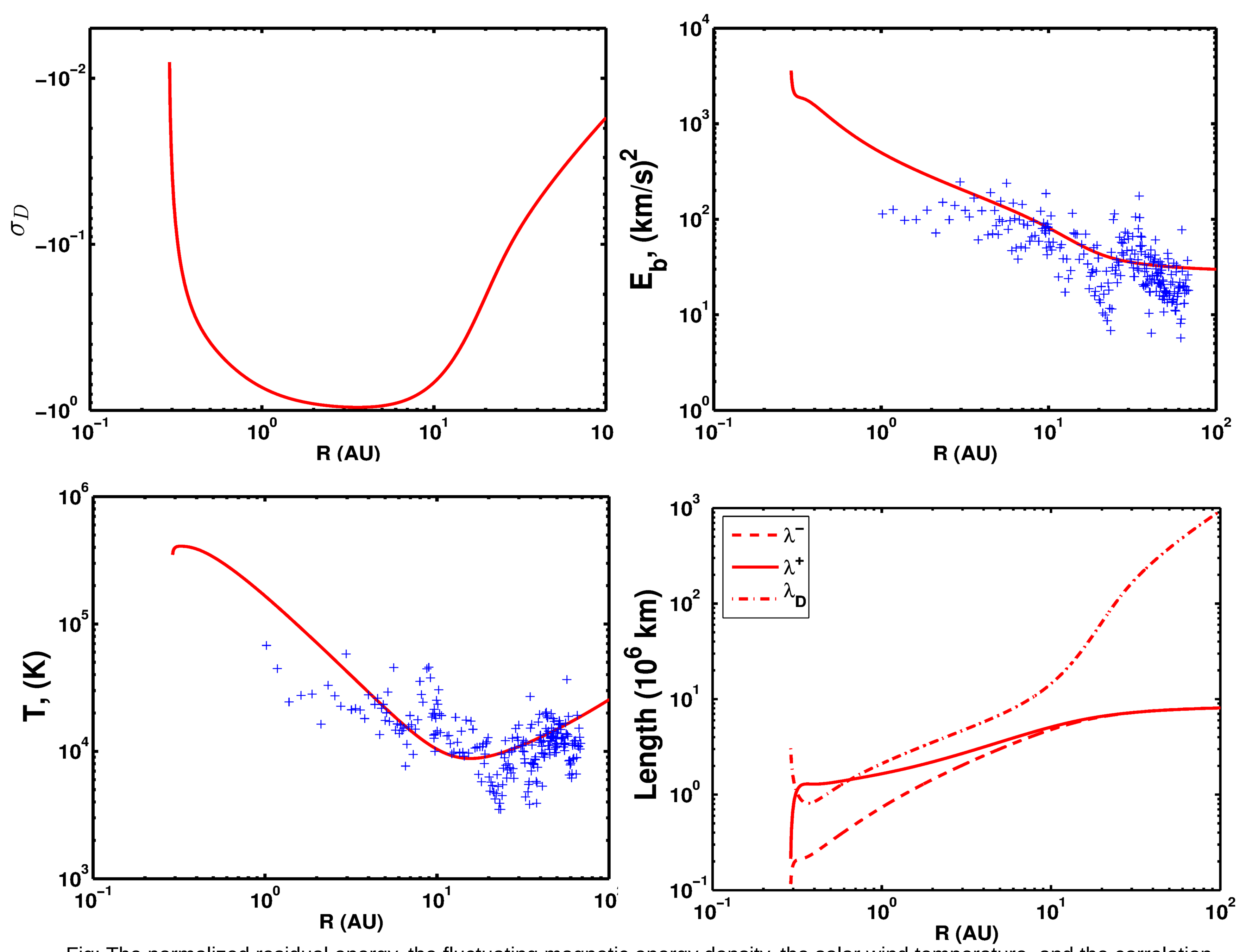

Fig: The normalized residual energy, the fluctuating magnetic energy density, the solar wind temperature, and the correlation lengths as a function of radial distance in a clockwise direction from top to bottom. The scattered diagrams are the corresponding observed values.

Key Findings

Inner heliosphere (Theory)	Inner heliosphere (Observations)
The energy in forward propagating modes decays with increasing heliocentric distance.	Observations agree.
The generation of backward propagating modes is predicted in the inner heliosphere.	Increase observed in Helios data at between ~0.3 – 1 AU.
The correlation lengths are predicted to increase and be approximately equal.	The three correlation lengths are approximately equal.

Outer heliosphere (Theory)	Outer heliosphere (Observations)
The solar wind temperature increases beyond 20 AU.	Observations agree.
The fluctuating magnetic energy density decreases with increasing heliocentric distance.	Observations agree.
The normalized residual energy is approximately -1 between 1 and 10 AU, and increases towards zero beyond 10 AU.	Observations show that the normalized residual energy is close to -1 between 1 and 5 AU.

Impact

- Turbulence levels impact scattering of highly energetic particle and cosmic rays.
- This work has a considerable impact on our understanding of the particle radiation environment at the Earth.

Explanation

- The coupling and the transport of energy in the large-scale solar wind is mediated by small-scale turbulence.
- Through the dissipation of turbulent energy, the solar wind is heated.

Magnetized turbulence and the large-scale solar wind are therefore intimately and dynamically coupled to one another.

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