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Solar Wind and Kinetic Heliophysics - Hannes Alfven Medal Lecture at the EGU General Assembly 2018

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This lecture reviews recent aspects of solar wind physics and elucidates the role Alfven waves play in solar wind acceleration and turbulence, which prevail in the low corona and inner heliosphere. Our understanding of the solar wind has made considerable progress based on remote sensing, in-situ measurements, kinetic simulation and fluid modelling. Further insights are expected from such missions as the Parker Solar Probe and Solar Orbiter.

The sources of the solar wind have been identified in the chromospheric network, transition region and corona of the sun. Alfven waves excited by reconnection in the network contribute to the driving of turbulence and plasma flows in funnels and coronal holes. The dynamic solar magnectic field causes solar wind variations over the solar cycle. Fast and slow solar wind streams, as well as transient coronal mass ejections are generated by the sun's magnetic activity.

Magnetohydrodynamic turbulence originates at the sun and evolves into interplanetary space. The major Alfven waves and minor magnetosonic waves, with an admixture of pressure-balanced structures at various scales, constitute heliophysical turbulence. Its spectra evolve radially and develope anisotropies. Numerical simulations of turbulence spectra have reproduced key observational features. Collisionless dissipation of fluctuations remains a subject of intense research.

Detailed measurements of particle velocity distributions have revealed non-maxwellian electrons, strongly anisotropic protons and heavy ion beams. Besides macroscopic forces in the heliosphere local wave-particle interactions shape the distribution functions. They can be described by the Boltzmann-Vlasov equation including collisions and waves. Kinetic simulations permit us to better understand the combined evolution of particles and waves in the heliosphere.