Work areas and publications of Eckart Marsch

Quantum Physics of Condensed Matter (Correlations, Magnetism, and Solid-State Transport; 1974-1978)

Abstract of the content

The work on the physics of condensed matter arose in the context of my diploma and doctoral thesis. They deal with electronic correlations (by Coulomb interaction) in narrow conduction bands of transition metals (such as Fe, Co, and Ni), and with magnetism and electronic transport (described by thermodynamic response functions) in such materials. The underlying theory is based on the Hubbard model. After the discovery of high-temperature superconductivity, work was also done on antiferromagnetism and high-temperature superconductivity.

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Solar wind physics (phenomenology, models, kinetics, turbulence, Coulomb collisions, and wave-particle interactions; 1976-2017)

Abstract of the content

The work on the physics of the solar wind is concerned with its phenomenology and its models in the context of the plasma fluid description but also in detail with the micro-state of the solar wind. This requires a deep understanding of plasma kinetics and turbulence, Coulomb collisions between ions and electrons, and wave-particle interactions in the plasma of interplanetary space. Thereby the focus is on the evaluation of measurement data from space probes (in particular from the Helios mission) together with their theoretical interpretation. The empirical papers listed cover a very broad range of topics and methods, with the aim of comprehensively understanding the characteristics and dynamics of the solar wind. Some oft the papers with the velocity distribution functions of the ions and spectra of the magnetohydrodynamic fluctuations of flow and magnetic field (as well as the radial gradients) described there were groundbreaking for modern space plasma physics. A review article on turbulence became a classic of solar wind literature.

1. Rosenbauer, H., R. Schwenn, E. Marsch, B. Meyer, H. Miggenrieder, M. D. Montgomery, K.-H. Mühlhäuser, W. Pilipp, W. Voges, and S. M. Zink, A Survey on Initial Results of the HELIOS Plasma Experiment, **J. Geophys., 42**, 561–580, 1977.
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Physics of the solar corona (EUV spectroscopy, coronal sources of solar wind, plasma kinetics and plasma waves in the corona; 1994-2013)

Abstract of the content

The work on the physics of solar corona deals with the EUV spectroscopy of the transition zone and corona of the sun and with the sources of the solar wind in the chromospheric network. The data are evaluated in the context of plasma kinetics and with respect to plasma waves in the corona, and are analyzed and interpreted by taking into account the extrapolated magnetic field of the corona. The formation of the solar wind in the funnels of the network in coronal holes is a fundamental discovery that is described in some empirical papers (but also in models). Model calculations for fractionation of elements in the chromosphere are presented. The kinetic plasma physics of the solar corona is discussed in an often cited review article. Two extensive reviews describe results, experimental and methodological aspects as well as instrumental fundamentals of solar ultraviolet spectroscopy.

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Theoretical space plasma physics (kinetics, turbulence, plasma waves; 1980-2015)

Abstract of the content

The work in the context of theoretical space plasma physics deals with topics from the plasma kinetics, the magnethydrodynamic and kinetic turbulence, as well as waves in the plasma in its description as a fluid or as a multi-component kinetic medium. Transport properties are calculated by Coloumb as well as wave-particle interactions. Analytical methods and numerical simulations are used to study turbulence and its energy cascade. In particular, the dissipation of turbulence (along with heating and acceleration of particles) is discussed. The dispersion properties of different waves are analyzed and the decay of large-amplitude Alfvén waves is investigated and simulated. Aspects of intermittency in plasma are also investigated.

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Miscellaneous from Space Physics (Missions, instruments and populars; 1989-2012)

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Relativistic quantum mechanics and quantum field theory (wave equations and gauge field theory; 2005-2017)

Abstract of the content

This theoretical work deals with relativistic equations for charged elementary massive particles in quantum mechanics and quantum field theory. The properties of the Dirac and Majorana equation are further analyzed and discussed in new ways. The hydrogen atom is recalculated as a binary relativistic system (with isotope effect). On the basis of the SU (N) (with N = 2,4,8) group theory and the internal symmetries of the Dirac equation, a new unified field theory for fundamental fermions and bosons is proposed.

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