to obtain satisfactorily exact descriptions of electromagnetic properties of complex material media one is enforced to use methods and approximations which are difficult to control. Moreover, they usually break covariance properties and the results obtained are valid in one reference frame which choice remains subjective and model dependent.

Some time ago we have proposed a reformulation of Maxwell electrodynamics which opens new ways in study of electromagnetic processes in material media. The formalism gets rid of assumptions characteristic for vacuum electrodynamics only and it avoids the usage of constitutive relations as primary relations put on quantities needed for a complete description of an electromagnetic system. Fundamental properties of all electromagnetic quantities are their uniquely defined transformation rules and their analysis allows to determine the possible relations between them. Within such a scheme it is possible to introduce constitutive relations which do not have analogies in macroscopic classical electrodynamics. They may be used in description of microscopic electromagnetic processes in a different way than it is done in the framework of quantum electrodynamics.

Magnetic Field due to Spin-Polarized Nucleons in Neutron Stars

M. Kutschera

A model of the ferromagnetic origin of magnetic fields of neutron stars is developed [1]. We assume that a ferromagnetic phase transition occurs inside neutron star cores soon after the formation. However, due to a high electric conductivity, the core magnetic field is initially fully screened. We study how this magnetic field emerges for an outside observer. After some time, the induced field which screens the ferromagnetic field decays enough to unshield a detectable fraction of the ferromagnetic field. We conjecture that weak fields of millisecond pulsars, $\sim 10^8 G$, could be identified with ferromagnetic fields which are sufficiently unshielded in 10^8 years.

Reference:

1. M. Kutschera, "Emergence of Magnetic Field due to Spin-Polarized Baryon Matter in Neutron Stars", IFJ Report **1806/PH** (1998).

Mesonic and Quark Degrees of Freedom in the Neutron Star Matter

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It is expected that mesonic and quark degrees of freedom may play an important role in the physics of dense matter in neutron stars. Any conclusions, however, as to the presence of e.g. meson condensates and/or quark matter inside neutron stars are subject to uncertainties which reflect incompatible model predictions at a purely nucleon level [1].

In our project, as far as mesonic contributions to the equation of state of dense matter are concerned, we focus on the role of kaons and the isovector scalar meson $a_0(980)$ [2]. We find that a threshold density for the kaon condensate to form is very sensitive to a high density behaviour of the electron chemical potential, which is not well known due to uncertainties of nucleon-nucleon interactions. An important effect of the inclusion of the a_0 meson is a splitting of proton and neutron masses in the neutron star matter [2].

A proper construction of the nucleon-quark phase transition in dense neutron star matter predicts that nucleons and quarks coexist over a finite range of pressure, with quarks (nucleons) filling gradually larger (smaller) fraction of space. We find, using a simple bag-model equation of state for the quark matter, that properties of such a mixed quark-nucleon phase are determined by the behaviour of nucleon matter isobars which is sensitive to the nuclear symmetry energy at high densities [3]. We study also implications of the presence of a mixed phase for the structure of neutron stars.

References:

1. M. Kutschera, Acta Phys. Pol. B **29** (1998) 25;
2. S. Kubis, M. Kutschera, and S. Stachniewicz, Acta Phys. Pol. B **29** (1998) 809; "Neutron Stars in Relativistic Mean Field Theory with Isovector Scalar Meson", in: "Nuclear Astrophysics", eds M. Buballa, W. Nörenberg, J. Wambach, A. Wirzba, GSI Darmstadt, 1998;
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QCD Pomeron in $\gamma\gamma$ and $\gamma^*\gamma^*$ collisions

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The reaction $\gamma\gamma \to J/\Psi J/\Psi$ is discussed assuming dominance of the QCD BFKL pomeron exchange. We give prediction for the cross-section of this process for LEP2 and TESLA energies. We solve the BFKL equation in the non-forward configuration taking into account dominant non-leading effects which come from the requirement that the virtuality of the exchanged gluons along the gluon ladder is controlled by their transverse momentum squared. We compare our results with those corresponding to the simple two gluon exchange mechanism and with the BFKL pomeron exchange in the leading logarithmic approximation. The BFKL effects are found to generate a steeper t-dependence than the two gluon exchange. The cross-section is found to increase with increasing CM energy W as $(W^2)^{2\lambda}$. The parameter λ is slowly varying with W and takes the values $\lambda \sim 0.23 - 0.28$. The magnitude of the total cross-section for the process $\gamma\gamma \to J/\Psi J/\Psi$ is found to increase from 4 to 26 pb within the energy range accessible at LEP2. The magnitude of the total cross-section for the process $e^+e^- \to e^+e^- J/\Psi J/\Psi$ with antitagged e^+ and e^- is estimated to be around 0.1 pb at LEP2.
We analysed the BFKL pomeron contribution to the $\gamma*\gamma*$ collision at high energy incorporating the dominant non-leading effects. We confronted our results with the recent preliminary data from LEP for two tagged leptons and gave predictions for the future linear colliders.

Penetration of the Earth by Ultrahigh Energy Neutrinos Predicted by Low x QCD

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We calculate the cross sections for neutrino interactions with (isoscalar) nuclear targets in the energy domain all the way up to 10^{12} GeV. Small x QCD effects are included by using a unified BFKL/DGLAP formalism which embodies non-leading $ln(1/x)$ contributions. The few free parameters which specify the input parton distributions are determined by fitting to HERA deep inelastic data. The attenuation of neutrinos transversing the Earth at different nadir angles is calculated for a variety of energy spectra for neutrinos originating from different sources (from Active Galactic Nuclei, Gamma ray bursts, top-down models), as well as for atmospheric neutrinos. For this purpose we solve the transport equation which includes regeneration due to neutral current neutrino interactions besides attenuation.