values of the radial coordinate in the conformally coupled massless case. The nontrivial topology is essential also in the opposite asymptotic limit, where the magnitudes of VEVs are increasing by a power-law.

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Electrical conductivity for hot and dense astrophysical plasma

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We investigate the electrical conductivity of hot and dense plasma relevant to the outer crusts of neutron stars and the interiors of white dwarfs. The main novelty of the work is the inclusion of positrons in the composition of matter and in the transport. We solve a system of coupled Boltzmann kinetic equations for electrons' and positrons' distribution functions in the relaxation time approximation, taking into account the electron-ion, positron-ion and electron-positron collisions. The relevant scattering matrix elements are calculated from one-plasmon exchange diagrams with the inclusion of in-medium polarization tensors derived within the hard-thermal-loop effective theory. Preliminary numerical results are obtained for matter consisting of carbon nuclei. We found that the conductivity rises with the temperature following a power-law $\sigma \propto T^4$ in the nondegenerate regime because of intense creation of thermal electron-positron pairs.
These results highlight the importance of inclusion of positrons in the transport of heated dense astrophysical plasmas.

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Urca cooling of the neutron star in the Cassiopeia A supernova remnant

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Observed cooling rate of the young neutron star (NS) in the Cassiopeia A supernova remnant (Cas A NS) exceeds theoretical expectations based on conventional scenarios of NS cooling, controlled mainly by modified Urca (mUrca) neutrino emission. Several hypotheses have been suggested to explain these observations. The most popular one assumes the cooling enhancement by neutrino emission due to the Cooper pair breaking and formation (PBF) just after the onset of neutron superfluidity in the NS core. This explanation requires strict constraints on critical temperatures of proton and neutron superfluidities in the NS core and on the efficiency of the PBF cooling mechanism. These constraints are in tension with the modern theory. To relax them, Lev Leinson (2022) suggested a hybrid cooling scenario, where the direct Urca (dUrca) process of neutrino emission from a small NS central kernel contributes to the cooling enhancement in addition to the PBF process. We show that Cas A NS cooling needs not to be hybrid, as the joint effect of Urca (dUrca+mUrca) processes can explain the observations equally well with or without superfluidity and the PBF mechanism. We explore the Urca scenario with different assumptions about NS equation of state, baryon superfluidity, and composition of the outer heat-blanketing envelope. We show that the observed cooling rate can be reproduced with many combinations of these assumptions by tuning the NS mass, which should slightly exceed the threshold mass for opening the dUrca process in the kernel. Then the core stays non-isothermal for centuries, delaying the onset of enhanced dUrca cooling to satisfy the Cas A NS observations. In addition, we present an analytic toy model which elucidates many features of the Urca scenario. The work was supported by the Russian Science Foundation Grant No.24-12-00320.

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X-ray pulse profile as a new probe for dark matter halo around neutron stars

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X-ray telescopes—NICER, eXTP, ATHENA, and STROBE-X—offer a promising probe of the structure of compact objects such as neutron stars. A dark-matter halo surrounding these objects alters the local space-time and, in turn, affects light propagation. In this work, we examine the impact of forming a self-interacting bosonic dark-matter halo around neutron stars, aiming to identify signatures that may shed light on the nature of dark matter.

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Antikaon Condensed Dense Matter In Neutron Star with SU(3) Flavour Symmetry

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Observations of massive pulsars indicate that the core densities of compact stars can greatly exceed nuclear saturation density, possibly giving rise to exotic forms of matter such as hyperons, meson condensates, and quark matter. Among meson condensates, anti-kaon (K^-) condensation stands out as a promising candidate, though the nature of kaon-meson interactions remains incompletely understood. Employing SU(3) flavor symmetry, we compute hadronic couplings in the mesonic sector, building upon and refining previous quark model approaches. Important parameters—including the mixing angle (θ_v), the octet-to-singlet coupling ratio (z), and the symmetric-to-antisymmetric weight factor (α_v)—are determined, with α_v treated as a free parameter. Our findings demonstrate that increasing α_v leads to a stiffer equation of state, postpones the onset of K^- condensation, and results in higher neutron star masses. The K^- condensation emerges through a second-order phase transition, with its onset being highly sensitive to the value of α_v.

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Relativistic corrections and three-nucleon forces in neutron star matter