Project of Vladimir N. Kondratyev for the JINR University Center

Title: NEUTRINOS FROM DYNAMO-DRIVEN SUPERNOVAE

Introduction. Supernova (SN) explosions (flares) represent one of the most powerful, spectacular and bright phenomena in the Universe [1]. Such events display a sharp (10^8 – 10^{10} times) increase in the star's luminosity, plausibly, give sites for synthesis of heavy nuclides, update other nuclear components, generation of strong neutrino bursts and high-energy cosmic rays and so on. Accordingly, the origin of these phenomena and relevant processes attract considerable attention. Neutrino- and dynamo-driven explosions are considered nowadays as main mechanisms of energy transfer to the entire stellar material of the pre-supernova (pre-SN or the precursor star, initially bound by gravitational forces), powering SN events and a strong glow.
Modern simulations of SN phenomena [2] and analysis of nucleosynthesis processes [3,4] show that multidimensional effects, for example, convection and instability of stellar plasma can significantly enhance magnetic induction to extremely high field strengths reaching tens of teratesla (TT). The observations of magnetars provides additional evidence strong magnetization at SN phenomena, see [5].

Project description. This project aims to consider the neutrino dynamics in hot and dense magnetized matter corresponding to a supernova explosion. In particular, we analyse the Fokker-Planck equation describing the dynamics of the neutrino phase space distribution function accounting for fluctuations. The respective kinetic coefficients in the equation are determined by energy transfer and straggling in neutrino collisions with a magnetized nucleon gas due to the neutral current Gamow-Teller interaction [6]. When accounting for the effect of fluctuations, the switching of acceleration and deceleration modes of neutrino dynamics remains for average energy. The effect of fluctuations leads to an additional increase in the hardness of the neutrino spectra. It is expected that the high-energy component of the electron antineutrino flux is enhanced in addition due to the effect of neutrino oscillations. Such an increase in the high-energy component of the spectrum is especially noticeable in the case of the inverted mass ordering and makes the signal more registrable by ground-based detectors. The possibilities of detecting supernova neutrinos by KM3NeT and Baikal-GVD observatories [7] will be discussed.

The problems for students:
1. Derivation of kinetic coefficients in the Fokker-Planck equation.
2. Solution of the Fokker-Planck equation. Analytical and numerical.
3. Investigation of possibilities of detecting supernova neutrinos by ground-based detectors.

Results of the project will be presented in the form of the report considered as a version for scientific paper.

Number of the participants: The number of the participants is one or two students.

References

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