Project of Vladimir N. Kondratyev for the JINR University Center

International Student Internship (ISI) Project on "Nucleosynthesis in Strong Magnetic Fields"

Introduction. Magnetic effects can influence properties of atomic nuclei, as is well known from studies of hyperfine interactions [1], when fields generated by the electronic environment at surfaces of atomic nuclei can reach megateslas (MT). Various phenomena, e.g., heavy-ion collisions, magnetar crusts, core-collapse supernovae, neutron star mergers, etc., are accompanied by significantly larger ultrastrong magnetizations [2] up to tens of terateslas (TT), which influence processes involving atomic nuclei, see [3–5] and references therein. Such strong magnetic fields can alter the nuclide composition of materials, that requires consideration of possible magnetic influence on the structure and transmutations of nuclides. Implications of relevant data in the analysis of nucleosynthesis and nuclear transformation chains can provide a more detailed understanding of the relevant phenomena.

The work description. This work aims to familiarize with magnetic effects in the structure of atomic nuclei and perspectives of radioactive nuclide implications to probe internal fields in processes mentioned above. For small field strengths of ~MT, the nuclear g-factors provide a quantitative description of nuclear magnetic properties [1]. In the case of magnetic inductions of ~TT similar quantities are described by the nuclear magnetic susceptibility [3–5]. It is planned to pay particular attention to the consideration of the Zeeman splitting of nucleon energy levels in the structure, properties and isotopic composition of stellar plasma in respect with e- and r-process scenarios. The titanium problem solution demonstrates one of achievements of taking into account magnetic effects in nucleosynthesis and indicates further perspectives for realistic detailed interpretation of the abundance of chemical elements while taking into account nuclear magnetism.

The problems for students:

1. Derivation and analysis the nuclear magnetic susceptibility at field strength of ~TT.
2. Investigation of nucleosynthesis at strong magnetization.
3. Revealing properties of nucleosynthesis sites by making use of radioactive nuclides.

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

1. P.Ring, P.Schuck, *The Nuclear Man-Body Problem* (Springer: Berlin/Heidelberg, Germany, 1980).
2. G.S.Bisnovatyi-Kogan, *Stellar Physics* (Springer-Verlag, Berlin, 2011),
3. V.N. Kondratyev, *Zeeman energy in nucleosynthesis at strong magnetization in supernovae.* Mon. Not. R. Astron. Soc. **480**, 5380 (2018) , https://doi.org/10.1093/mnras/sty2248
4. V.N.Kondratyev, *R-Process with Magnetized Nuclei at Dynamo-Explosive Supernovae and Neutron Star Mergers.* Universe **7**, 487 (2021) , https://doi.org/10.3390/universe7120487
5. В.Н.Кондратьев, *Намагниченные ядра в r-процессе*. Изв. РАН с. Физ. **89**, 1216–21 (2025), *Magnetized Nuclei in the r-Process*. DOI: 10.1134/S1062873825711973

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