REVIEW

of a domestic scientific consultant on the dissertation work of
Yernazarov Tursynbek Izmukhanovich

"The effects of nonlinear vacuum electrodynamics and general relativity for the passage of the front of electromagnetic waves through the magnetic field of the magnetar",

submitted for the degree of Doctor of Philosophy (PhD)
of the educational program in "8D05306-Physics"

Recent studies have demonstrated the nonlinear nature of vacuum within quantum electrodynamics, particularly through inelastic scattering of laser photons on gamma-quanta. Observing these effects in a laboratory setting requires exceptional measurement accuracy (10^{-19}–10^{-20}), currently beyond the capabilities of modern instruments. Consequently, our understanding of vacuum nonlinear electrodynamics remains limited. However, extreme conditions like the super-strong magnetic fields around magnetars offer a more conducive environment for observing these effects. In such fields, electromagnetic wave propagation exhibits nonlinear phenomena like ray bending and polarization changes. While analytical and numerical studies have explored refraction angles and polarization in magnetic fields, quantitative research on these effects in off-equatorial planes and under the combined influence of gravity and nonlinear vacuum electrodynamics is scarce. Comparing these findings with satellite telescope data could enhance our understanding of vacuum nonlinear effects, making this research area highly relevant.

This work employs numerical methods to investigate vacuum nonlinear electrodynamics and gravity's impact on electromagnetic radiation propagation through a magnetar. It examines ray deflections in the dipole axis plane and the perpendicular plane under the combined influence of gravitational and magnetic fields. The study reveals that the beam's deflection angle depends on the collision parameter and magnetic field strength at distances ranging from 15 to 100 km for a magnetic field of $B = 10^{13}$ G. Maximum deflection angles reached 86° for the gravitational field and 3.36° for the magnetic field. Additionally, the research analyzes the deformation of the radiation front traversing the magnetic field, finding an almost elliptical shape with an index of $\Delta = 0.07$. A significant influence of combined fields on the gamma-ray flux density from GRB091006360 was observed as it passed through the magnetar Swift J1822.3-1606 magnetosphere, leading to energy flux redistribution.

This doctoral study holds significant implications for future research in astrophysics and vacuum nonlinear electrodynamics. The investigation of combined gravitational and magnetic fields' influence on electromagnetic radiation offers a deeper understanding of nonlinear vacuum electrodynamics (NLED) effects under conditions impossible to replicate in terrestrial laboratories. This work lays the

groundwork for studying such effects in distant astrophysical objects, including magnetars and neutron stars.

Furthermore, refining gravitational and magnetic lens models will be crucial for accurately interpreting observations of objects with strong magnetic fields. The data on electromagnetic radiation energy redistribution as it passes through the magnetar magnetosphere is particularly valuable for understanding high-energy astrophysical environments like gamma-ray bursts.

The dissertation's findings have been published in domestic and international scientific journals and presented at scientific conferences and seminars. The research was conducted under the Ministry of Education and Science of the Republic of Kazakhstan's scientific research plans, within the priority area of natural sciences research. It was funded by grant IRN AP14869524, titled "Effects of nonlinear electrodynamics of vacuum and general relativity on magnetars".

Yernazarov Tursynbek Izmukhanovich successfully completed all assigned tasks, fully achieving the dissertation research goals. His work meets the requirements for a Doctor of Philosophy degree. I recommend that the Academic Council accept the dissertation for public defense, leading to the conferral of a Doctor of Philosophy in Natural Sciences, specializing in "Physics".

Reviewer:
Domestic scientific consultant,
PhD, senior lecturer of KazNU Aimuratov Y.K.