

## Brief information about the project

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| Name of the project                                                                                                                | AP26195069 «Bound states in Maxwell, Yang-Mills, Proca theories with and without gravity in the presence of spinor fields»                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Relevance                                                                                                                          | The relevance of this study lies in the fact that new spherically and axially symmetric solutions will be obtained within the aforementioned theories, which can be interpreted as quasiparticles in the plasma of such theories.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Purpose                                                                                                                            | Study of soliton-like solutions in Maxwell, Yang-Mills, Proca, and Dirac theories, with and without the inclusion of a gravitational field, aimed at investigating their applicability for describing quasiparticles (bound states) in plasma of these theories. Revelation of differences and common properties between the resulting plasma and a quark-gluon plasma in QCD.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Objectives                                                                                                                         | Obtaining finite-energy solutions in Maxwell, Yang-Mills, Proca, and Dirac theory, both with and without gravity. For systems without gravity, interpretation of the obtained solutions in the context of describing bound states in the plasma of the corresponding theories, which serves as an analogue of the quark-gluon plasma in QCD.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Expected and achieved results                                                                                                      | <p>Expected results: Establishing a connection between various field theories and quantum theory, which describes the strong interaction.</p> <p>Achieved results: Regular finite-energy solutions have been obtained in the Yang-Mills-Proca theory with external sources. It is shown that the color electric and magnetic fields possess two components: the first is the gradient/curl component, respectively, and the second is a nonlinear component. It is demonstrated that the color electric field exhibits a Y-shaped spatial distribution. This Y-shaped behavior arises due to the gradient component of the electric field. The nonlinear component of the electric field is vortical in nature and emerges due to the vector potential generated by a solenoidal current. The color magnetic field is purely curl-type, since its nonzero color components lack a nonlinear contribution, which leads to its field lines lying on the surface of a torus.</p>                                                                                                     |
| Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles | <ol style="list-style-type: none"> <li>1. Dzhunushaliev Vladimir Dzhumakadyrovich, Professor, Doctor of Physics and Mathematics, h-index – 24, ResearcherID: : <a href="http://www.researcherid.com/rid/N-7008-2014">http://www.researcherid.com/rid/N-7008-2014</a>. ORCID: <a href="https://orcid.org/0000-0001-9479-5606">https://orcid.org/0000-0001-9479-5606</a>). Scopus Author ID: <a href="http://www.scopus.com/inward/authorDetails.url?authorID=55887756300&amp;partnerID=MN8TOARS">http://www.scopus.com/inward/authorDetails.url?authorID=55887756300&amp;partnerID=MN8TOARS</a></li> <li>2. Folomeev Vladimir Nikolaevich, Professor, Doctor of Physics and Mathematics, h-index – 21. ResearcherID: AAR-1843-2020. ORCID: 0000-0003-4160-5850. Scopus Author ID: 23034434500</li> <li>3. Dina Zholdakhmet. h-index – 1. ORCID: 0000-0003-0584-3544 ResearcherID: GZM-4537-2022.</li> <li>4. Alibekova Juldyz. h-index – 0. ORCID:0009-0007-4288-5256 ResearcherID: LJL-9526-2024.</li> <li>5. Raushan Berkutbaeva. h-index – 0. ORCID: 0009-0003-1217-</li> </ol> |

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| Usage                                        |                                                                                                                                                                                                                                         |
| Priority compared to real-world alternatives | For the first time, a Y-shaped spatial distribution of the color electric field has been obtained for three static quarks.                                                                                                              |
| List of publications with links to them      |                                                                                                                                                                                                                                         |
| Patents                                      |                                                                                                                                                                                                                                         |
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