Iranian Journal of Physics Research, Vol. 26, No. 1, 2026
DOI: 10.47176/ijpr.26.1.82175

Laser beam effect on particle-particle entanglement in two-temperature dense quantum plasma

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(Received 21 August 2025 ; in final form 25 October 2025)

Abstract

Entanglement is an inherently quantum phenomenon, and particle-particle scattering can generate quantum entanglement depending on the interaction potential between the two particles. The theoretical evaluation of the entanglement generated during particle-particle scattering is carried out using entanglement fidelity. The particle-particle interaction potential is modified in the presence of other particles, such as those in a plasma environment, and under an external electric field induced by a laser. Consequently, quantum entanglement becomes a function of plasma and laser parameters. In this study, a dense two-temperature plasma environment consisting of electrons and ions is considered, which can exhibit either classical or quantum behavior, including quantum diffraction and exchange symmetry, while an external electric field (laser) is also present. The interaction of the laser with plasma particles excites oscillations and modifies the plasma dynamics, all of which can be incorporated into the effective particle-particle interaction potential. Therefore, the effects of plasma parameters, such as temperature and density, as well as laser intensity, on entanglement can be directly analyzed. The results show that low collision energy, low plasma temperature, high particle density (or short Debye length), and specific ranges of laser intensity lead to an enhancement of quantum entanglement. Furthermore, in an electron-ion plasma, the electron temperature plays a much more significant role in entanglement dynamics than the ion temperature.

Keywords: Quantum entanglement, Quantum dense plasma, Laser, Entanglement Fidelity, Effective potential

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