RESEARCH HIGHLIGHT & PUBLIC SUMMARY

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Published in: Progress of Theoretical and Experimental Physics (PTEP), Vol. 2026, 063B04 (25 pages) | DOI: https://doi.org/10.1093/ptep/ptag089

PTEP

Prog. Theor. Exp. Phys. **2026** 063B04 (25 pages)
DOI: 10.1093/ptep/ptag089

Valence Quark Distribution of the Pion Inside a Medium with Finite Baryon Density: A Nambu–Jona-Lasinio Model Approach

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Received January 20, 2026; Revised May 14, 2026; Accepted May 15, 2026; Published May 20, 2026

We calculate the in-medium valence quark distribution of the pion immersed in a finite baryon density using the light-cone quark model. The medium-modified pion properties are obtained using the constituent quark mass-dependent light-cone wave functions. To obtain the constituent quark mass at a finite baryon density, we employ the two-flavor Nambu–Jona-Lasinio model. We focus primarily on the in-medium electromagnetic form factor, distribution amplitude, and parton distribution function of the pion. The parton distribution functions are also evolved from the model scale to a perturbative scale using next-to-leading-order Dokshitzer–Gribov–Lipatov–Altarelli–Parisi evolution equations. Furthermore, our calculated form factors are compared with available experimental measurements and lattice quantum chromodynamics studies. We also examine the Mellin moments derived from our parton distribution functions in comparison with existing extractions and theoretical model predictions.

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A plethora of short-lived particles have been discovered over the last century, broadly classified into **Fermions and Bosons**. Among bosons, the **pion** is particularly special as the lightest meson (mass ~250 × electron). Pions are bound states of up/down quarks held by the strong force. Due to their rapid decay, their internal structure is explored indirectly at facilities like **Jefferson Lab (JLab)** and the future **Electron-Ion Collider (EIC)** at BNL. In this work, in-medium pion properties in a dense baryonic environment were investigated using the NJL model framework.

Key Discoveries & Technical Highlights: As surrounding baryon density increases, the pion decay constant decreases while its charge radius increases. Electromagnetic form factors and PDFs were evolved to perturbative scales using NLO DGLAP evolution equations and evaluated against lattice QCD.

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Funding Acknowledgments: Supported in part by BRNS, DAE (Govt. of India), Ministry of Education (MoE), and SERB-POWER Fellowship.