# Density matrix expansion for the isospin- and momentum-dependent MDI interaction

J. Xu and C. M. Ko

Using the density matrix expansion [1,2], we have obtained an effective zero-range Skyrme-like interaction with density-dependent parameters [3] from the finite-range exchange interaction of the isospin- and momentum-dependent MDI interaction [4] that has been extensively used in studying isospin effects in intermediate-energy heavy-ion collisions [5] as well as the properties of hot nuclear matter [6] and neutron star matter [7]. We have then used the resulting interaction to determine the transition density and pressure at the inner edge of neutron star crusts based on the linearized Vlasov equation for the neutron star matter. From the latest constraint $L = 58 \pm 18$ MeV on the density slope of the nuclear symmetry energy [8], the transition density and pressure are constrained within 0.050 fm$^{-3}$ < $\rho_t$ < 0.071 fm$^{-3}$ and 0.12 MeV/fm$^3$ < $P_t$ < 0.31 MeV/fm$^3$ for T=0 MeV, and 0.038 fm$^{-3}$ < $\rho_t$ < 0.070 fm$^{-3}$ and 0.06 MeV/fm$^3$ < $P_t$ < 0.30 MeV/fm$^3$ for T=1 MeV as shown in Fig. 1. Although the transition density is smaller at fixed L compared to previous results, which leads to a smaller crustal fraction of the moment of inertia for neutron stars and an even stricter constraint on the masses and radii of neutron stars, the upper limit values of $\rho_t$ and $P_t$ are larger because of the smaller values of L. The final constraint on the neutron star mass-radius relation is expected to be similar to that in the previous work.
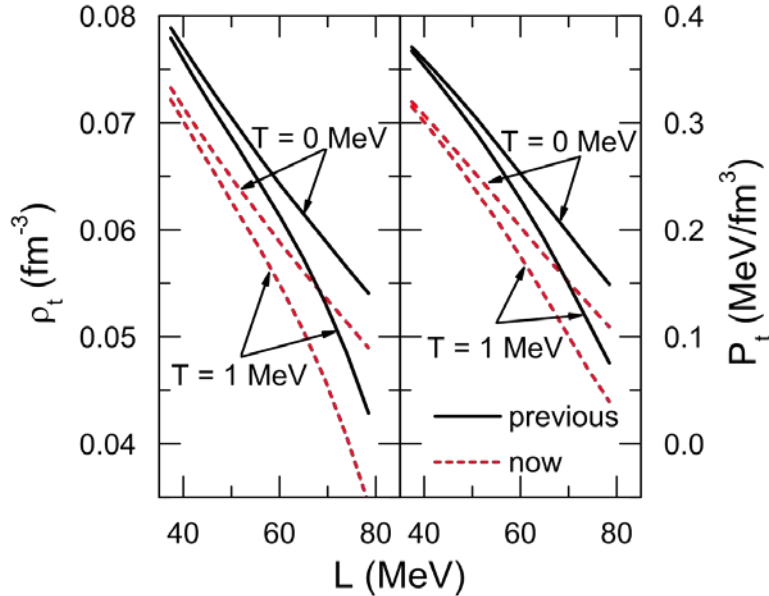


**FIG. 1.** The transition density $\rho_t$ and pressure $P_t$ at the inner edge of neutron star crust as functions of the density slope parameter L of the nuclear symmetry energy for T=0 MeV and T=1 MeV from the MDI interaction [4] (solid lines) and from its density matrix expansion (dashed lines) [3].

[1] J.W. Negele and D. Vautherin, Phys. Rev. C **5**, 1472 (1972).

[2] D.W. Sprung, M. Vallieres, X. Campi, and C.M. Ko, Nucl. Phys. **A253**, 1 (1973).

[3] J. Xu and C.M. Ko, Phys. Rev. C **82**, 044311 (2010).

[4] C.B. Das, S. Das Gupta, C. Gale, and B.A. Li, Phys. Rev. C **67**, 034611 (2003).

[5] L.W. Chen, C.M. Ko, and B.A. Li, Phys. Rev. Lett. **94**, 032701 (2005).

[6] J. Xu, L.W. Chen, B.A. Li, and H.R. Ma, Phys. Rev. C **77**, 014302 (2008).

[7] J. Xu, L.W. Chen, B.A. Li, and H.R. Ma, Phys. Rev. C **79**, 035802 (2009).

[8] L.W. Chen, C.M. Ko, B.A. Li, and J. Xu, Phys. Rev. C **82**, 024321 (2010).