Divergence of the isospin asymmetry expansion of the nuclear equation of state

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We have extracted [1] from realistic chiral nuclear interactions the quadratic, quartic, and sextic terms in the isospin-asymmetry expansion of the equation of state of nuclear matter at finite temperature,

$$F(T,\rho,\delta) \simeq \sum_{n=0}^{N} A_{2n}(T,\rho)\,\delta^{2n}\,, \tag{1}$$

from second-order many-body perturbation theory. In the bottom-right panel of Fig. 1, we observe that the quadratic coefficient A_2 describes well the global isospin asymmetry dependence from symmetric nuclear matter to pure neutron matter by comparing to the symmetry energy $F_{sym} = F(T,\rho,\delta=1) - F(T,\rho,\delta=0)$. The higher-order terms, however, are shown to be large and alternating in sign (see the top-right and bottom-left panels of Fig. 1) at low temperature and high density, indicating a divergent

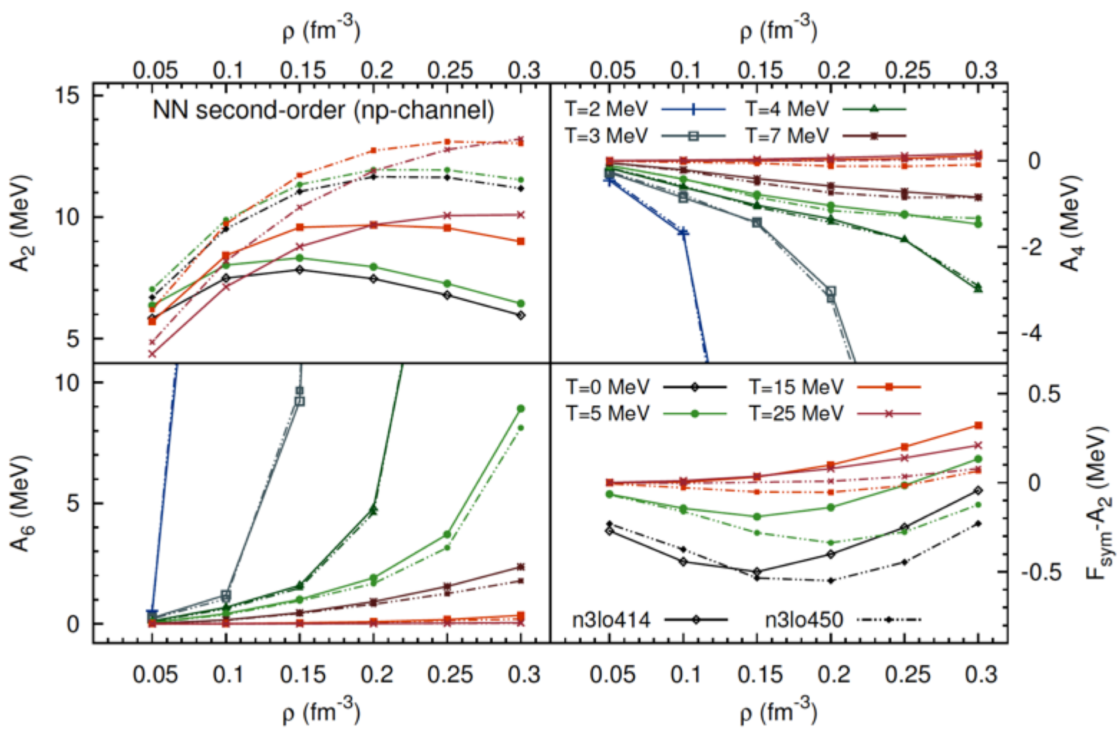

FIG. 1. Coefficients of the Maclaurin expansion for the isospin-asymmetry dependence of the nuclear equation of state as a function of temperature and density from two chiral nuclear force models. The difference between the nuclear symmetry energy $\boldsymbol{F_{sym}}$ and the $\boldsymbol{A_2}$ coefficient is shown in the bottom-right panel.

series incompatible with the traditional assumption in Eq. (1). In Ref. [2] it was shown that at zero temperature an *S*-wave contact interaction gives an additional logarithmic contribution to Eq. (1) when computed at second order in perturbation theory. Extracting this nonanalytic term leads to a significant improvement in the description of the free energy per particle at large isospin asymmetries. In future work these results will be used to study the crust-core transition density in neutron stars and the threshold density for the onset of direct URCA processes relevant for neutron star cooling.

[1] C. Wellenhofer, J.W. Holt, and N. Kaiser, Phys. Rev. C **93**, 055802 (2016).
[2] N. Kaiser, Phys. Rev. C **91**, 065201 (2015).