Contribution ID: **63**

Type: **not specified**

On the use of charge distributions to constrain effective interactions

Tuesday, December 10, 2024 10:35 AM (40 minutes)

The key ingredient for mean-field calculations in nuclear structure is the effective interaction which models the strong force in the nuclear medium. Such interactions usually depend on a set of parameters fitted to properties nuclei and infinite nuclear matter. These interactions can suffer several limitations and problems. For example, since they are usually adjusted on properties of observed nuclei close to the valley of stability, their predictive power for exotic and super-heavy nuclei may be questionable. Furthermore, unphysical finite-size instabilities can sometimes appear when these interactions are used to calculate properties of nuclei which have not been considered to constrain their parameters. These instabilities can appear in various channels and therefore have scalar, vector, isoscalar or isovector characters. It was shown that the formalism of the linear response in infinite-nuclear matter can be used to avoid such instabilities for the construction of zero-range interaction (of Skyrme type). Although such a formalism was also developed for finite-range interactions (Gogny type), the calculations for the linear response are much more time-consuming and can hardly be incorporated in the procedure used to fit their parameters. I will discuss how the scalar-isovector instabilities are related to the distributions of protons and neutrons in nuclei and how, in turn, information on charge density distributions can be used to prevent these instabilities. Beside the avoidance of instabilities, information about the charge distribution may lead to a better balance between the different contributions to the binding energy of nuclei and their evolution with mass and asymmetry. I will show that the use of constraints on charge distributions from a set of chosen nuclei can be used to avoid the appearance of scalar-isovector instabilities and discuss how this could improve the predictive power of the mean-field calculations.

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Session Classification: Nuclear interaction