Relativistic Mean Field Models with Generalized Coupling

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Effective relativistic mean field models of the Walecka type have enjoyed great success in recent years for the description of nuclear structure, in particular, with non-linear meson self couplings. An alternative was proposed recently in our group with density dependent couplings [1], which is also suggested by many body theory. It was shown that this yields a comparably good description of nuclear ground states. It is of interest to generalize such models to effectively momentum dependent couplings, which is also suggested by Brueckner theory, and which is demanded by the energy dependence of the optical model. An empirical, universal parametrization of energy-dependent coupling constants was developed recently [2].

An alternative, and formally more consistent approach, is a formulation with meson-nucleon coupling constants depending on scalar field operator products, which contain derivatives of the fields, as e.g. $i\bar{\psi}\gamma^\mu\partial_\mu\psi$. This leads to effectively momentum dependent self energies. As a further possibility we added terms to the Lagrangian which couple mesons to derivatives of the nuclear field, as e.g. $i\bar{\psi}\gamma^\mu\partial_\mu\psi\sigma^2$. This can be cast into the form of density dependent masses. We find that it is possible to find parametrizations, which describe not only nuclear masses but also the energy dependence of the optical potential.=20

The density and momentum dependence of the self energies can be further tested in collective excitations (and also in heavy ion collisions). We are discussing collective excitations in nuclear matter in a linear response approach in phase space [3], at the moment for non-linear and density dependent models. This has also been extended to the case of a symmetric nuclear matter and the question of instability regions. It will be of interest to be able to treat finite nuclei in this way.

References

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Superheavy and Hyperheavy Nuclei in the Form of Bubbles or Semi-bubbles

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We present a comparison of our model treating fission dynamics in conjunction with light-particle (n, p, α) evaporation with the available experimental data for the nuclei ^{126}Ba, ^{188}Pt and three isotopes of the element $Z = 110$. The dynamics of the symmetric fission process is described through the solution of a classical Langevin equation for a single collective variable characterizing the nuclear deformation along the fission path. A microscopic approach is used to evaluate the emission rates for prefission light particles. Entrance-channel effects are taken into account by generating an initial spin distribution of the compound nucleus formed by the fusion of two deformed nuclei with different relative orientations.