PAIRING CORRELATIONS BEYOND MEAN FIELD: FROM FINITE NUCLEI TO NEUTRON STARS

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Pairing correlations in atomic nuclei are often taken into account at the mean-field level using the BCS gap equation with phenomenological interactions, like Skyrme and Gogny forces.

In uniform neutron and nuclear matter, however, it is well known that several processes (self-energy renormalization, vertex corrections, interaction induced by phonon exchange) renormalize substantially the pairing gaps obtained in mean field theory. It is an open question how to perform similar calculations in finite nuclei, where the presence of the surface plays an essential role.

We have performed a systematic study of the effects of the coupling between particle and vibrations on the superfluidity of atomic nuclei. Using the Nambu-Gorkov equations, which take into account in a consistent way self-energy processes, vertex renormalization and the interaction induced by the exchange of phonons, we have been able to show that in ^{120}Sn about one half of the pairing gap, as deduced from the experimental odd-even mass differences, originates from such effects, the other half being produced by the bare nucleon-nucleon interaction.

We are also able to compare the contributions of surface and spin vibrations, understanding the different role played by the induced interaction in atomic nuclei - where it increases the pairing gap - and in uniform neutron and nuclear matter, where it leads to a reduction.

The calculations performed in uniform matter can also be used to assess the superfluidity of the inner crust of neutron stars, which, according to the present understanding, consists of a Coulomb lattice of nuclei neutron-rich nuclei permeated by a sea of unbound neutrons. However, the coexistence of the two phases is seldom taken into account. In this contribution, we instead investigate such proximity effects on the pairing gap of the system, both at the mean-field level and taking into account renormalization effects. We find that the presence of nuclei can affect the calculated pairing gaps up to 50%.

Our results should lead to a quantitative calculation of the thermal properties of the inner crust and of the vortex pinning, considered to be the origin of the glitches phenomenon.