Pairing correlations around the drip-line of finite systems, and beyond

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I. SCIENTIFIC ISSUE

Pairing correlations are an essential ingredient of nuclear-structure models, in particular in view of describing exotic nuclei [1, 2]. Superfluidity also plays a key role in neutron stars, e.g., it impacts post-glitch timing observations [3] and their cooling history [4].

The existence of such correlations among nucleons moving in time reversal states was suggested by Bohr, Mottelson and Pines [5] in 1958, enlightening the possible analogy among the excitations spectra of finite nuclei and those of superconducting metallic states. It has thus been shown that nucleons moving close to the Fermi energy in time reversal states have the tendency to form Cooper pairs which eventually condense, in an exactly parallel way to what happens to superconducting electrons in standard superconductivity. Already in 1959, Migdal suggested that also neutron stars could also be superfluid [6].

Such extra correlations among nucleons manifest for example through the odd-even mass staggering, *i.e.* an even-even nucleus has an extra energy contribution compared to an odd-odd one due to the pairing correlations among nucleons. While in the case of low-temperature superconductivity the attraction among electrons is generated by the exchange of lattice vibrations (phonons) [7], in the nuclear case the origin of the pairing interaction is related to the $^1\mathrm{S}_0$ phase shift of the free nucleons, which is attractive at low relative momenta.

Pairing correlations in nuclei have been widely studied within the framework of the Nuclear Energy Density Functional Theory (NEDF). Such a method has the advantage of describing the evolution of structure phenomena from medium mass systems to superheavy nuclei, and from the valley of β-stability to the particle drip-lines and neutron stars [8]. It is directly derived, although with some important differences, from the famous Density Functional Theory (DFT). This method has been successfully applied to atomic, molecular and condensed matter physics, as recognized by the 1998 Nobel Prize awarded to Walter Kohn [9].

In keeping with the fact that the free nucleon-nucleon interaction is strongly renormalized in nuclei [10], it is of crucial importance to correctly determine the functional (or the effective interaction) that one should use to achieve a good description of experimental observables.

Many groups have focused their attention of the particle-particle part of the functional to describe different phenomena related to nuclear superconductivity. In particular they have studied the impact of pairing correlations on

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ground state properties of finite nuclei using both quantal approaches [11–15] or semiclassic methods [16]; the excitation energy of the first 2^+ state [17] or the properties of two-particle transfer reactions [18] According to the most recent astrophysical models describing stellar evolution of neutron stars, there is a strong request to improve the microscopic description of the crust of such astrophysical object. Only recently, such microscopic models have been systematically applied to such systems to perform microscopic calculations for different quantities as the equation of state [19, 20], the superfluid properties of the crust [21–24] and its specific heat [25, 26]. Of particular interest is to understand the properties of nuclear superfluidity for systems with chemical potential close to zero (*i.e.* close to the drip-line and beyond) [27]. Superfluidity plays a crucial role in determine the neutron drip line [28] and thus it has a strong impact on astrophysical models as for example the r-process nucleosynthesis or the transition form the outer crust to the inner crust in neutron stars.

II. GOALS OF THE WORKSHOP

In summary, the goals of the workshop are

1. To present the recent results obtained by different groups working on nuclear superfluidity applied to different systems, with particular emphasis to very neutron rich, and exchange informations and advances;

2. To explore the possibility of combining the informations obtained in nuclear structure and astrophysical cases and try to have more strict constraints on the pairing functional for wide application in nuclear physics;

3. To takle the physics of two overlapping superfluids such as dilute nuclei beyond the drip-line

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IV. PROGRAM

	27 May	28 May	29 May
9h45	Welcome		
10h00	Pastore	Robledo	Margueron
11h00	Break	Break	Break
11h30	Potel	Khan	Chamel
12h30	Lunch	Lunch	Lunch
14h00	Viñas	Bennaceur	Gambacurta
15h00	Assie	Jodon/ Pantel	Discussion
16h00	Break	Break	Break
16h30	Duguet	Schuck	**End**
1730	Discussion	Discussion	
18h00	**End**	18h00 **End**	