Unveiling proton-neutron pairing in homogeneous and isotropic nuclear matter

Betania Backes[1], Jacek Dobaczewski[1,2], Valentin Guillon[3], and Karim Bennaceur[3]
[1]University of York, UK, [2]University of Warsaw, Poland, [3]Université Claude Bernard Lyon 1, France

Pairing correlations play a crucial role in nuclear physics: their effects go from the odd-even mass staggering in nuclear structure, to the phases of matter found in neutron stars. As the strong interaction governs both nuclei and such astrophysical objects, a universal energy density functional (EDF) should be able to reproduce the properties of both vastly different systems. To this end, the nucleon pairing gaps in infinite nuclear matter (INM) are key ingredients to adjust new EDFs, which should be suitable to describe both astrophysical phenomena and finite systems. A link between gap equations of INM and the isospin symmetry of the Hartree-Fock-Bogoliubov wave function may be assumed straightforwardly. However, what is the true relationship between the structure of the pairing tensor and the wave function itself?

To address this question, we propose a different approach to the problem of proton-neutron pairs in INM, building our knowledge “from the bottom up”: we start from a wave function with a combination of all different ST channels, and from it, we obtain the most general density matrix and pairing tensor of nuclear matter. Our interaction-independent analysis shows that although the different channels separate in the Thouless matrix, they mix in the pairing tensor and the density matrix. We further explore which pairing channels are allowed to form in INM.