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# Recent results from the NUMEN project

The physics of neutrinoless double beta ($0\nu\beta\beta$) decay has important implications on particle physics, cosmology and fundamental physics. It is the most promising process to access the effective neutrino mass. To determine quantitative information from the possible measurement of the $0\nu\beta\beta$ decay half-lives, the knowledge of the Nuclear Matrix Elements (NME) involved in the transition is mandatory. The possibility of using heavy-ion induced double charge exchange (DCE) reactions as tools toward the determination of the NME is at the basis of the NUMEN project [1]. The basic points are that the initial and final state wave functions in the two processes are the same and the transition operators are similar, including in both cases a superposition of Fermi, Gamow-Teller and rank-two tensor components. Full understanding of the DCE reaction mechanism is fundamental to disentangle the reaction part from the nuclear structure aspects relevant for the $0\nu\beta\beta$ decay NMEs. One of the most debated aspect in the DCE and SCE nuclear reactions is the competition between the direct process, proceeding via the meson-exchange paths, and the sequential ones proceeding through the transfer of several nucleons.
The availability of the MAGNEX large acceptance magnetic spectrometer [2] for high resolution measurements of the DCE reactions is essential to obtain high resolution energy spectra and accurate cross sections at very forward angles, including zero degree, and allows the concurrent measurement of the other relevant reaction channels (elastic and inelastic scattering, one- and two-nucleon transfer and single charge exchange reactions). The strategy applied to study such a full net of reactions is to measure the experimental data in the same experimental conditions and analyze them using state-of-the-art nuclear structure and reaction theories in a unique comprehensive and coherent theoretical framework. This multichannel approach has been recently applied to analyze some nets of nuclear reactions, for example involving the $^{18}$O + $^{40}$Ca and $^{18}$O + $^{12}$C systems. Moreover, the absolute cross sections of some DCE reactions populating nuclei of interest for the $0\nu\beta\beta$ decay have been measured for the first time. These results will be presented and discussed at the Conference.

[1] F.Cappuzzello et al., Eur. Phys. J. A 54 (2018) 72.
[2] F.Cappuzzello et al., Eur. Phys. J. A 52 (2016) 167.

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