Long-range versus short range correlations in two neutron transfer reactions

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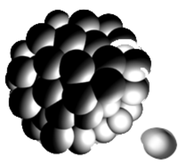
Abstract

We have performed exact finite range cross section calculations using the coupled channel Born approximation (CCBA) and coupled reaction channel (CRC) method for the sequential and direct two-neutron transfers, respectively. The microscopic interaction boson model (IBM-2) and interacting boson-fermion model (IBFM) has been applied to two-neutron transfer reaction. From our results we conclude that for two-neutron transfer to the ground state of ^{66}Ni the direct transfer is the dominant reaction mechanism, whereas for the transfer transfer of the first excited state of ^{66}Ni the sequential process dominates. A competition between long-range and short-range correlations is discussed.

Motivation



A better understanding of the nuclear structure and reactions will help to improve the model calculation of nuclear reactions, decays, such as Single Beta decay and Double Beta decay. The knowledge of the internal degrees of freedom is crucial to understand nuclear structure features like: collectivity states, ,single particle states,pairing properties ,clustering by means of elastic reactions, inelastic reactions single and two nucleon transfer reactions.

Two nucleon transfer

Transfer reactions

Two nucleons transfer can be used as a test of pairing correlations in nuclei.

Therefore one has to identify:

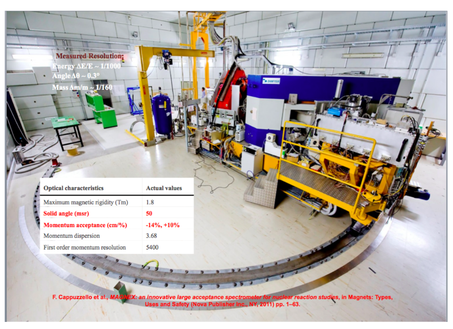
- If the two-neutron transfer occurs in one step (direct), under strong influence of pairing correlations or in two steps (sequentially).
- If the ground state of the residual nucleus is feed from the ground state of the target

In previous works has been noticed that direct two neutron transfer are important like in ^{12}C(^{18}O,^{16}O)^{14}C[1]

Therefore we want study the collectivity properties of the nuclei

The two neutron transfer ^{64}Ni (^{18}O,^{16}O)^{66}Ni

- The experimentalists performed the two-neutron transfer of ^{18}O+^{64}Ni at 84 MeV incident energy, to the ground and first excited state of the residual ^{66}Ni nucleus.
- Therefore to study this reaction we require compute the spectroscopic factors and cross sections for two neutron transfer.

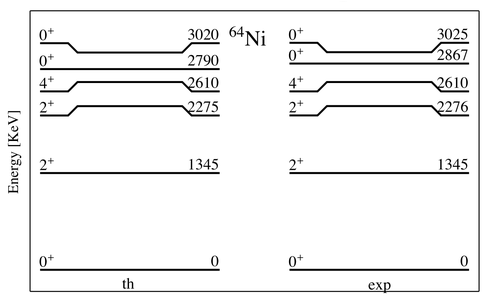


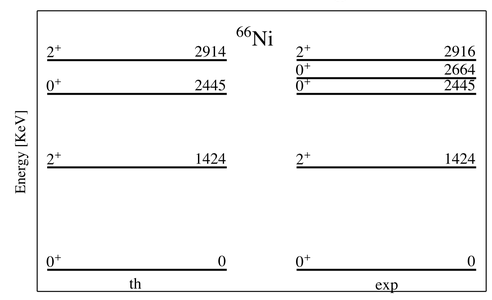
- All the experimental data were measured by the large acceptance MAGNEX spectrometer at the INFN- Laboratori Nazionali del Sud (Italy)

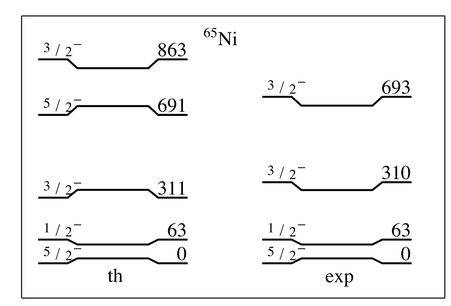
Method

The even-even nuclei ^{64}Ni and ^{66}Ni and odd-even ^{65}Ni nucleus

For the ^{64}Ni and ^{66}Ni it is required consider the basic features of the effective nucleon-nucleon interaction, that emerge from pairing, quadrupole and symmetry energy. We have calculated the theoretical spectrum of the ^{64,66}Ni nuclei coming from IBM2[2] and it is in accordance with the experimental data and we have calculated the theoretical spectrum of the ^{65}Ni nucleus using the interacting boson fermion model (IBFM) [2]



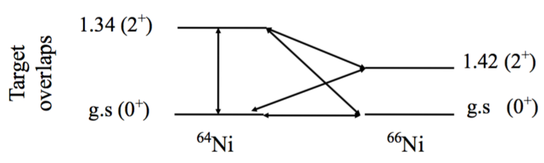




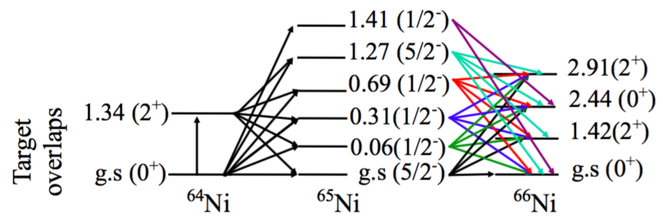
Coupling Scheme

In order to proceed with the calculation, we propose a coupling scheme:

For the direct two-neutron transfer reaction(or one step mechanism) we use microscopic IBM-2



For sequential transfer (or two-step mechanism) we use IBFM



Transfer operator

The calculation of the spectroscopic amplitudes for the two nucleon transfer reactions in the scheme of IBM2 requires the two body matrix elements in the scheme the Generalized Seniority Scheme [4]

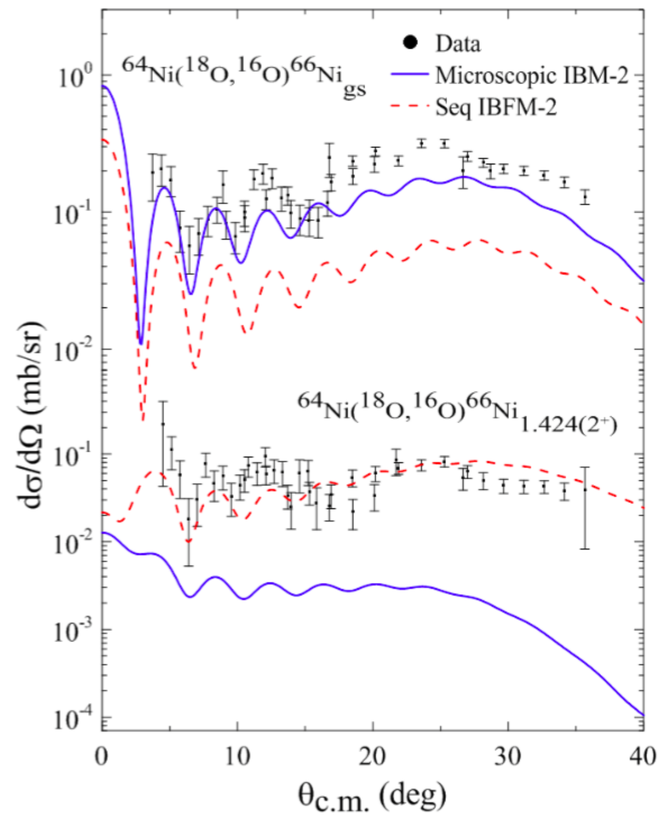
The matrix elements between fermionic states in the collective subspace are identical to the matrix elements in the bosonic space, therefore taking into account the Otsuka- Arima -Iachello (OAI) expansion to the next to leading order (NLO)[7] we can obtain the two nucleon transfer operator.

The advantage of this operator is that the effects of the pairing interaction are in terms of the occupation of different single-particle orbitals and the two body matrix elements take into account the non-degenerate orbits of the GS states.[5]

The calculation of the spectroscopic amplitudes for single nucleon transfer reactions has been performed in the IBFM scheme[6]

The coupled channel Born approximation (CCBA) has been used for the the sequential two neutron transfer. The Coupled reaction channel (CRC)has been used for direct two neutron transfer.

Results and Conclusions



- For the transfer reaction to the ground state ^{66}Ni, both two reaction mechanisms are important.
- For the transfer to the ground state of ^{66}Ni, the pairing correlation seems to be relevant, specially at the bell shape maximum region.
- For the two-neutron transfer to the first excited state of the ^{66}Ni, there is a dominance of the two step processes.
- These results allows us to conclude that the pairing correlation effects is present in the two transferred neutrons to the ground state. This state has is weak collectivity because ^{66}Ni, is not full deformed, is vibrational.
- However for the 2_1^+ state of ^{66}Ni, so the long range correlation between nucleons are dominant over short range paring correlations of two neutrons.
- In previous experiments the forward angle oscillations were not observed because they were not able to measure the forward angles.[3]
- It is interesting to observe that for the same nucleus different states prefer different transfer mechanism.

References

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