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Super-radiance and two-neutron transfer reactions *

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Super-radiance was first studied by Dicke [1] within the context of coherence effects in spontaneous radiation processes. Since then, the phenomenon has been referenced in many areas of modern science, among them: quantum optics, condensed matter, biophysics, and nuclear physics (See the reviews in Refs. [2,3]).

In atomic nuclei, seen as a complex open quantum many-body system, the effect arises from the coupling to continuum states that can be treated in terms of a non-hermitian hamiltonian (non-hermitian super-radiance). Increasing coupling to the continuum leads to the separation of long-lived and short-lived (super-radiant) resonance states.

In a recent Nature physics communications [3], Volya and collaborators reported strong evidence for the phenomenon in alpha cluster decays of mirror nuclei ^{18}O and ^{18}Ne . The authors state that “these findings may be the clearest manifestation of the super-radiance in nuclear physics to date.”

In this work we study the effect of continuum coupling on two-neutron transfer reactions such as (t,p). Following the framework discussed in Ref. [3], we consider the simple case of a two-level model to obtain two-neutron transfer amplitudes (TNAs). Our results show a clear transition between the normal and super-radiance regimes, which is marked by a sharp reduction of the ground-state to ground-state transition strength, being now shared between the long-lived and super-radiant resonance states.

Some examples of possible experimental studies, where the effect could be observed, will be discussed.

[1] R. J. Dicke, Phys. Rev. 93, 99 (1954).

[2] N. Auerbach, V. Zelevinsky, Rep. Prog. Phys. 74, 106301 (2011)

[3] I. Rotter, J.P. Bird, Rep. Prog. Phys. 78, 114001 (2015)

[4] A. Volya, M. Barbui, V. Z. Goldberg, and G. V. Rogachev, Nature Comm. Physics 5:322 (2022)

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Collaboration

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