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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 18O and 18Ne. 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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