Role of exact treatment of thermal pairing in radiative strength functions of ^{161,163}Dy nuclei[†]

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The photon or radiative strength function (RSF), defined as the average electromagnetic transition probability per unit of γ-ray energy E_γ,[1] has an important role in the study of nuclear reaction properties such as γ-ray emission rate, reaction cross section, and/or nuclear astrophysical processes.[2] Very recently, we have proposed a microscopic model to simultaneously describe the nuclear level density and RSF.[3] For the RSF, we employed the phonon damping model (PDM),[4] which consistently includes the exact thermal pairing (EP), in order to take into account both temperature-dependent giant dipole resonance (GDR) width (within the PDM) and thermal pairing (within the EP). The goal of the current work is to shed a light on the microscopic nature of the low-energy enhancement in the RSF data caused by the PDR (Pygmy Dipole Resonance). Three dysprosium isotopes ^{161,162,163}Dy are selected to do the calculations within the EP+PDM. The results will be compared with the phenomenological models (standard Lorentzian-SLO and generalized Lorentzian-GLO) and the other microscopic model (Quasiparticle random-phase approximation-QRPA). The RSF at each energy E_γ and temperature T is defined as follow

$$f_{E1}(E_\gamma, T) = \left(\frac{1}{3\pi^2\hbar^2c^2}\right)\frac{\pi}{2}\frac{\sigma_{E1}\Gamma_{E1}(E_\gamma, T)S_{E1}(E_\gamma, T)}{E_\gamma}, \quad (1)$$

where σ_{E1} is the GDR cross section which is obtained microscopically within the PDM, Γ_{E1} is the temperature-dependent GDR width, and S_{E1} is the GDR strength function.

Figure 1 depicts the total RSFs obtained within the PDM with and without EP the experimental data[5] as well as those obtained within the microscopic D1M+QRPA ($E1$ and $E1 + M1$) and phenomenological GLO-SLO models. The results obtained show that, due to the effect of EP, the EP+PDM can describe reasonably well the RSF data in both low and high-energy regions without adding any extra strength function. As a result, at least eight free parameters have been reduced within the EP+PDM calculations as compared to the description by the phenomenological GLO-SLO model.

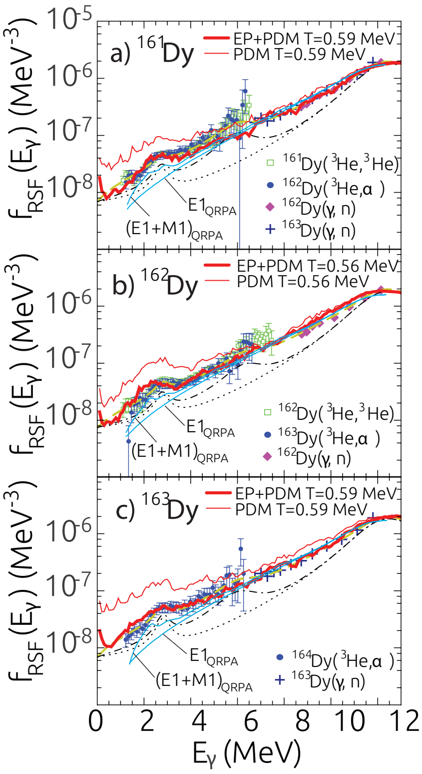

Fig. 1. Total RSFs obtained within the PDM (thin solid lines), EP+PDM (thick solid lines) versus the QRPA RSFs for the $E1$ and $E1 + M1$ excitations and the experimental data[5] for $^{161-163}$Dy. The dashed, dash-dotted, and dotted lines stand for the RSFs obtained within the phenomenological GLO-SLO models with 2 PDRs, 1 PDR, and without PDR, respectively.

Temperature is found to have a significant effect on the RSF at the low energy $E_\gamma \leq S_n$, whereas it does not change much the RSF in the high-energy one $E_\gamma > S_n$, questioning the validity of the Brink-Axel hypothesis. In addition, due to the effects of EP and couplings of all ph, pp, and hh configurations within the PDM, the EP+PDM can also partially reproduce the scissors resonance in $^{161-163}$Dy nucleus at low E_γ without adding a SR strength function in the RSF. These findings indicate the importance of EP and couplings to non-collective pp and hh configurations at finite temperature in the microscopic description of total RSF in excited nuclei.

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References
1) J. M. Blatt, V. F. Weisskopf, *Theoretical Nuclear Physics* (Wiley, New York, 1952).
2) J. Kopecky, M. Uhl, Phys. Rev. C **41**, 1941 (1990).
3) N. Q. Hung, N. D. Dang, L. T. Q. Huong, Phys. Rev. Lett **118**, 022502 (2017).
4) N. D. Dang, A. Arima, Phys. Rev. Lett. **80**, 4145 (1998).
5) https://www.mn.uio.no/fysikk/english/research/about/infrastructure/ocl/nuclear-physics-research/compilation/.