Description of Double Giant Dipole Resonances within the Phonon Damping Model

In a recent Letter [1], an overall agreement with the experimental data for the excitation of the giant dipole resonance (GDR) and double giant dipole resonance (DGDR) in relativistic heavy ion collisions (RHIC) in ^{136}Xe and ^{208}Pb nuclei has been reported. The phenomenological phonon damping model (PDM) has been used. The strong (about a factor of 2) enhancement of the DGDR cross section in ^{136}Xe [2], apparently reproduced in the Letter, has been a challenge for many years and in spite of several attempts (see, e.g., [3,4]), it remains open. In this Comment, we point out that the agreement with the experimental findings in Ref. [1] is achieved by a wrong calculation of the DGDR excitation mechanism.

To calculate the DGDR cross section, an expression [Eq. (6)] is used which is similar to the photoabsorption cross section with the GDR strength function replaced by the one of the DGDR. Then, it is inserted in Eq. (7) which thus describes the DGDR excitation in a direct or one-step process [5].

An essential difference between nuclear reactions with real and virtual (as in RHIC) photons is that multistep processes with the sequential absorption of two (three, etc.) virtual photons may take place in the last reaction. Theoretically, it is described, e.g., in the second (third, etc.) order perturbation theory [6,7]. The reduction of the two-step process to the one-step process is not possible on physical grounds.

Whether the DGDR is excited in RHIC in a one- or two-step process is presently not in question. First, microscopic calculations with no free parameters indicate that the two-step process is stronger by at least 2 orders of magnitude or even more [4]. Second, it has been proved experimentally [8].

Equation (6) contains a scaling factor $c^{(2)}$ which determines the absolute value of the DGDR cross section. It is computed by equating first order [Eq. (7)] and second order [Eq. (8)] expressions. To equate the values, known to be different by orders of magnitude (see above), appears to us not correct.

In addition, we find it difficult to call "microscopic calculations" the fits performed in the frame of the PDM to obtain strength functions, as done in [1], when the strength parameter F_{ph} changes by 2 orders of magnitude when contributions of higher-order processes to the damping of the GDR are included, as in the extension of the model in Ref. [9]. This means that the main mechanism for the GDR and DGDR widths is missed in Ref. [1] and that the agreement with the data is achieved by an unrealistically large value of F_{ph}. In Ref. [9] they claim that the higher-order processes may be effectively accounted for by renormalization of F_{ph}. This is not correct because the diagrams of high-order graphs (see Figs. 1b–1e in Ref. [9]) cannot be reduced to the diagram of the lowest-order one (Figs. 1a) with a renormalized vertex. Again, as for the cross section above, their "effective" treatment contradicts the "right physical content."

The PDM fits yield the value of F_{ph} in the heavier double-magic ^{208}Pb larger than in the lighter semimagic ^{136}Xe, while it is clear from general arguments that it should be the opposite.

In our opinion, any conclusion drawn from those calculations about the deviation of the DGDR properties from the harmonic limit expectations appears rather difficult to understand.

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[5] The DGDR has, in fact, components with quantum numbers 0^+ and 2^+. Thus, to calculate the photoexcitation of the DGDR (a process never observed because of the extremely small cross section [4]), the cross section should be cubic on the excitation energy and not linear as in Eq. (6).
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