Electromagnetic dipole strength distribution in ^{124,128,132,134}Xe below the neutron separation energy

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Abstract
Dipole strength functions in the chain of xenon isotopes are analyzed on the basis of photon-scatterde experiments with bremsstrahlung at the γELBE facility in Dresden, Germany, and at the HIγS facility in Durham, North Carolina, USA. The evolution of dipole strength with neutron excess and nuclear deformation is studied.

The results presented in this report are part of the work published in Ref. [1]. Electromagnetic strength functions are a suitable tool for describing the average transition strengths between nuclear states in the quasicontinuum. In connection with nuclear level densities the strength functions describe photo-excitation and -deexcitation of an excited states [2]. The dominant $E1$ strength is measured for a few nuclei so far. The prominent hump of the giant dipole resonance (GDR) can be approached with various phenomenological functions [3] resulting in different predictions for the strength function below the neutron-separation energy. However, for astrophysical calculations and simulations regarding reactor safety this part of the strength function is of crucial importance. As shown e.g. in Ref. [4, 5] one can describe the photon spectrum following neutron capture with an experimentally deduced strength function.

For most of the nuclei no information is available so far or may be ever available, because the majority of nuclides has very short lifetimes and the measurement is a challenging task. Nevertheless, these nuclides play an important role in the addressed calculations, because they occur as intermediate fission and fusion products, before decaying to stable nuclei. Therefore, global descriptions of strength functions are needed based on fundamental nuclear properties such as neutron and proton number. One important parameter is the nuclear deformation. For the GDR it was shown [6] that it changes the distribution of dipole strength around the resonance region.

With the goal to check the influence of deformation on the low-energetic part, experiments on several isotopes in the xenon chain have been performed at the bremsstrahlung facility of the Helmholtz-Zentrum Dresden-Rossendorf [7]. By measuring photoabsorption cross sections it is possible to deduce an electromagnetic strength function. Several steps of the analysis [9], such as simulations with GEANT4 [8] in to correct the spectra for background and detector response, as well as simulation with γDEX [4] to estimate inelastic scattering, are performed. This analysis ensures that the derived photoabsorption cross section includes not only information about visible peaks, but also the full information about the quasicontinuum of unresolved states.

Fig. 1 shows the experimental results in combination with predictions of various parametrizations. One can see that the description of the low-energy strength as the tail of a Lorentzian is not correct. It approaches the data in some cases, e.g. for the well deformed nucleus ^{124}Xe, but not for the almost spherical ^{134}Xe. A reason for this deviation may be the excess of neutrons in ^{134}Xe relative to ^{124}Xe,

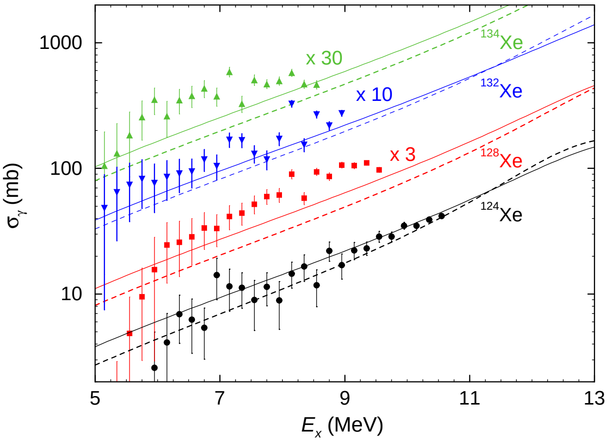

Fig. 1: Comparison of experimental deduced photo-absorption cross sections (colored circles) and predictions by the triple-lorentzian model ([6],solid lines) and the single-lorentzian description of RIPL3 ([3], dashed lines).

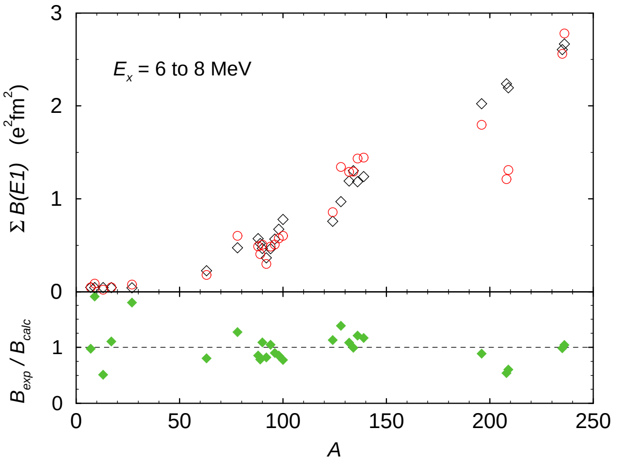

Fig. 2: Comparison of the prediction of the low-energetic strength with experimental information available in EXFOR [10].

as shown in Ref. [1]. It is possible to describe the strength below the neutron separation energy with the following equation:

$$\sum_{6-8\mathrm{MeV}} B(E1) \approx 0.08\frac{NZ}{A}\left(\frac{N}{Z}-1\right) \tag{1}$$

This formula is valid for a wide range of nuclei, as one can see in Fig. 2. It connects the fundamental properties such as neutron number N, proton number Z and mass number $A = N + Z$ with the strength. The formula shows that the distribution depends on the complete dipole strength, described with the Thomas-Reiche-Kuhn sum rule [11–13]. In addition, the neutron excess $(N/Z - 1)$ modifies the strength, whereas the nuclear deformation seems to be only of minor importance.

This work was supported by the German Research Foundation (DFG), project no. SCHW 883/1-1 and partly by the EURATOM FP7 Project ERINDA (FP7-269499). Partial support was also granted by the U.S. Department of Energy, Office of Nuclear Physics, under Grants No. DE-FG02-95ER4093, No. DE-FG02-97ER41033 and No. DE-FG02-97ER41042.

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