Symmetry Constraints for Nuclear Photon Strengths and their Importance for Nuclear Astrophysics and Nuclear Technology.

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A sum rule for the interaction of photons with nuclei has been derived by Gell-Mann, Goldberger and Thirring on the basis of very general symmetry requirements. By imposing certain conditions on the nucleon-nucleon interaction Bethe and Levinger had previously derived a sum rule for electric dipole transitions and the two formulations seem to leave very little leeway for strength of other multipolarity. A careful review of the situation with regard to novel experimental methods and results appears to be attractive. This is especially so as the photon strength function has turned out to be of special importance for predictions in the field of nuclear astrophysics and for possible procedures of use for the transmutation of nuclear waste.

In a series of experiments on heavy nuclei – partly performed at Rossendorf or with participation of scientists from Dresden – the existing data base was improved and extended by:

(a) Control and eventual correction of the absolute normalization of cross sections measured previously at photon beams obtained from positron disintegration in flight.

(b) Photon scattering and other experiments yielding information on photon absorption at energies below the threshold for the nuclear photo-effect.

(c) Polarization and angular distribution measurements which yield cross sections for multipolarities other than E1.

Additionally it was investigated if recent nuclear structure studies have an effect on the interpretation of photon strength data for heavy nuclei. Here the multiple Coulomb excitation results obtained by the Warsaw-Rochester collaboration are of special importance because of their model independent information on nuclear triaxiality. Whereas the effect of axial deformation on the form of the giant dipole resonance (GDR) is well acknowledged, the possible influence of non-axiality has been largely disregarded. When the low energy modes are accounted for in an adiabatic approximation, the extraction of a spreading width from GDR data is strongly influenced by a triaxial deformation. A respective reanalysis of old data leads to a surprisingly smooth dependence of the spreading width on the nuclear charge or mass number. And it agrees astonishingly well to sum rule predictions, much better than was stated previously.

The improved width information also is in very good accord to data for the absorption of low energy photons as derived by nuclear resonance fluorescence or from radiative capture data obtained in average resonance capture. The latter process is of large importance for the understanding of the stellar s-process as well as other astrophysical scenarios. It also influences the ratio of reaction rates for nuclear fission induced by fast neutrons as compared to neutron capture. Radiative capture increases the amount of actinides in nuclear reactor fuel which are unwanted because of their α-decay and their long half-lives. New concepts for power reactors producing less of that waste or for transmutation procedures need improved information on fission as well as on capture probabilities in actinide nuclei.