Experimental Report HE 810

Hyperfine Interactions in ^{161}Dy Compounds Studied via the Nuclear Lighthouse Effect

The aim of this experiment was the application of the recently discovered nuclear lighthouse effect [1,2] to the 25.6-keV resonance of ^{161}Dy. Compared to previous experiments at the resonances of ^{57}Fe [1,2], ^{119}Sn [3], ^{149}Sm [4], the challenge of this experiment was the operation of the rotors at low temperatures by cooling with a stream of cold nitrogen gas. This was necessary to induce a magnetic phase transition in Dy metal from a ferromagnetic state to an antiferromagnetic state with internal hyperfine fields of up to 600 T. The corresponding quantum beat periods around 100 ps can only be resolved with a conceptually new scattering technique. The nuclear lighthouse effect opens very promising perspectives in this field.

We have modified the existing rotor design used in previous studies for operation with cold nitrogen gas. In a first test experiment we achieved a stable operation for more than one hour at a temperature as low as 80 K. Unfortunately, all subsequent attempts to operate the rotor at this temperature failed for reasons that are not completely clear to date. After cooling down, the rotation was stable for a few minutes until it became unstable and finally stopped. During the following attempts to get back to stable operation, one rotor was destroyed. We got into touch with the vendor of the equipment to solve the problem, but were not successful. The most reasonable explanation for the negative result is the failure of the bearings at low temperatures. We are currently working out to improve these components and make them suited for operation at low temperatures. In addition, a new type of rotors has been developed together with a new cooling scheme that should be more reliable at low temperatures.

Instead of the originally planned experiment we used the remaining time to investigate small-angle x-ray scattering (SAX) from the rotors at high photon energies up to 60 keV. SAX is the strongest source of background in experiments using the nuclear lighthouse effect, preventing measurements at very early times. Due to its q^{-4} dependence it is expected that this background is significantly reduced at photon energies around 80 keV, so that isotopes with decay times in the range of a few ns should become accessible. This opens the possiblity to perform nuclear resonant scattering from many rare-earth resonances in this energy range [5]. Our experiments confirm the expected q - dependence. As a result, activities towards application of the lighthouse effect to high-energy resonances have already been initiated [3].

References

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