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The 31-yr isomer of  $^{178}\text{Hf}$  at excitation energy 2.446 MeV, and with  $J^\pi, K = 16^+, 16$ , has been the object of several studies for possible mechanisms that might trigger isomer decay to the ground state. Potential for the control of nuclear energies (MeV) with atomic energies (keV) is the driving interest. The  $^{178}\text{Hf}$  isomer is a favorite nucleus in the search for triggered decay because this isomer is long-lived, available in microgram quantities, the decay scheme is well known, the excitation energy is high, and a sample enriched in the isomer can be fabricated for irradiation. In fact, accelerated decay of the  $^{178}\text{Hf}$  isomer when irradiated with photons from a dental x-ray machine has been reported by Collins et al. [1]. The triggering x-ray energies were reported to be in the 20-60 keV range. Using the synchrotron radiation at the Advanced Photon Source (APS) we published [2] limits on such accelerated emission approximately 5 orders of magnitude lower than those in ref. 1. Very recently, a new measurement of triggering has been reported by Collins et al. [3], using monochromatic x rays from the SPring-8 synchrotron but this time for (several) much lower incident x-ray energies in the 9-13 keV region. In order to verify this observation, we undertook a new measurement at the APS, with significantly increased focus on incident x-rays below 20 keV, as described below.

Several thin Hf isomer targets were prepared by electrodeposition onto Be disks. Two such disks were clamped together with the depositions adjacent (and the Be surfaces exposed) to make a “sealed” target. This target was irradiated by a white beam from a tapered undulator at the SRI-CAT 1-ID beamline of the APS. The photons were collimated to a beam  $1.4 \times 2 \text{ mm}^2$ , and the target was placed at 45 degrees with respect to the incident beam. Gamma spectra were measured with a Ge detector placed at 90 degrees and at a distance of 22.9 cm. A set of Pb, Ta, Cd, and Cu absorbers covered the front face of the Ge detector. On the other side of the target chamber a Si(Li) detector to measure x-rays was placed at 90 degrees, 47.6 cm from the target center. A  $0.05 \times 0.05\text{-mm}^2$  collimator placed in front of the Si(Li) detector reduced the counting rate to a manageable level. The purpose of the Si(Li) detector was to provide a measure of the Hf fluorescent K x-rays, and in turn, the beam luminosity. The incident x-ray beam was cycled: 11 s beam on-target followed by two 11-s counting periods with the beam off-target. We analyzed data as in Ref. [2], that is, taking the difference between beam-on and beam-off spectra. We find no statistically significant difference in yield for  $^{178}\text{Hf}$  gamma-rays previously reported to show enhancement [1,3] over a wide range of incident x-ray energies, which includes all incident x-ray energies for which triggered decay has been claimed. An upper limit to the energy-integrated cross section for triggered isomer decay is shown in Fig. 1. This limit for triggered decay is many orders of magnitude below values reported [1,3] over the entire range of incident x-ray energies in question. More details of the APS investigation reported here are given in Ref. [4].

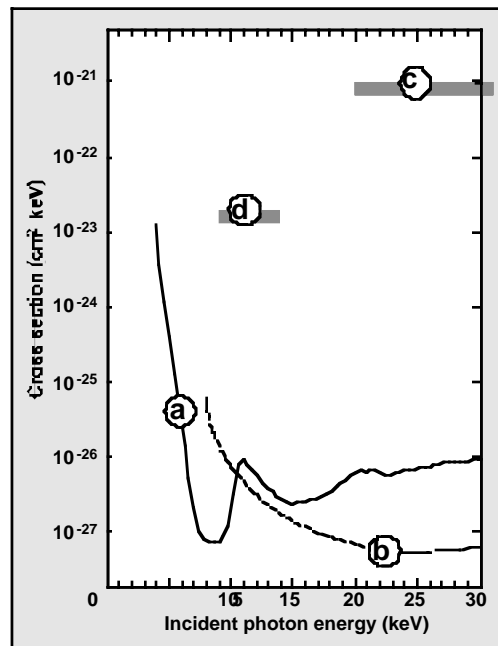


Fig. 1. Upper limit of the integrated cross section for x-ray induced decay of the 31-y  $^{178}\text{Hf}$  isomer for incident energies  $6 \leq E_x(\text{keV}) \leq 30$  deduced from the present measurement [Ref. 4] illustrated with a solid line (a). The limit from Ref. 2 is shown as dashed line (b). In comparison, cross sections values reported in Refs. 1 and 3 are shown as crossed hatched bars (c and d). (See also, results reported in Ref. 5.)

Preliminary survey experiments have been performed by another group [5] to examine the triggering of gamma emission from the 31-year  $^{178}\text{Hf}$  isomer using intense monochromatic synchrotron radiation from the X15A beamline at the National Synchrotron Light Source at Brookhaven National Laboratory. Initial studies were performed to probe incident photon energies over the L1, L2, and L3 X-ray edges of Hf and the 12–13 keV range. Resonances larger than the experimentally minimum detectable level of  $10^{25} \text{ cm}^2 \text{ keV}$  were not observed.

## References

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