

Figure 3 shows the part of the spectrum of the gamma rays for which emission was induced by absorption of low energy x-rays. It was obtained by subtracting the spectrum of spontaneous emission from the photons logged when the x-ray irradiation was turned off from the spectrum of spontaneous plus the extra induced emission logged at times when the x-ray irradiation was active. Since the gammas from the impurities is not affected by x-ray irradiation, the absence of any effect in the 181.56 keV line from ^{172}Lu is an ideal test to verify that the two data sets being subtracted to show the extra induced emission were properly scaled to reflect same times for the collection of data. Results shown in Fig. 3 for each of the two different levels of pulsed current through the x-ray source required the logging of data for about 100 hrs of operation.

3. CONCLUSIONS

The work reported here continues to confirm that the irradiation of samples of 4-qp isomers such as ^{178}Hf with x-rays at power levels of mW/cm^2 containing component lines and continua with end points greater than 20 keV[5] can materially increase the rate of decay of long-lived nuclear populations. In this case of ^{178}Hf the half-life for the storage of energy is 31 yr and the energy gain per triggering event exceeds 100-fold, making this a very interesting system. From Fig. 3 it can be appreciated that the released energy most readily detected is the result of transitions between members of the GSB excited in the course of the normal spontaneous decay. However the distribution of intensities differs. In the spontaneous decay the 8^+ level of the GSB is populated by the interband transition and the subsequent transitions occur in steps passing through each lower level in sequence. As a result all members of the GSB have about the same intensity in spectra of spontaneous emission. In contrast, the induced emission can be seen to be stronger in lines from transitions connecting lower members of the GSB. The x-rays excite the isomer to the mixing level from which electromagnetic transitions are no longer forbidden, but then by some path not yet identified, cascades of transitions convey the excited state population into lower members of the GSB without dropping them down in energy through the higher members. It has been indicated [5] that some newly observed lines have arisen from transitions through these induced cascades, but intensities in any one of the lines has been insufficient to fully explain the scheme of induced decay. It has been proposed that once induced, the decay from the mixing level proceeds through many parallel cascades, no one of them concentrating enough emission into a single spectral line for unequivocal detection. Current research objectives focus upon the collection of more data from which the additional decay cascades may be deduced.

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References

- [1] Collins C.B. in Proc. of the First International Induced Gamma Emission Workshop IGE '97, edited by I. I. Popescu and C. A. Ur (IGE Foundation, Bucharest, Romania, 1999), 1-17.
- [2] Further exploration of these nuclear analogies is available at the URL:
<http://www.utdallas.edu/research/quantum/isomer/tutorial.htm>
- [3] Collins C. B., Davanloo F., Dussart R., Iosif M. C., Hicks J. M., Karamian S. A., Ur C. A., Kirischuk V. I., Carroll J. J., Roberts H. E., Mc Daniel P., and Crist C. E., *Laser Phys.* **9**(1999) 8-11
- [4] Collins C. B., Davanloo F., Dussart R., Iosif M. C., Hicks J. M., Karamian S. A., Ur C. A., Popescu I. I., Kirischuk V. I., Carroll J. J., Roberts H. E., Mc Daniel P., and Crist C. E., *Phys. Rev. Lett.* **82** (1999) 695-698
- [5] Collins C. B., Davanloo F., Rusu A. C., Iosif M. C., Zoita N. C., Camase D. T., Hicks J. M., Karamian S. A., Ur C. A., Popescu I. I., Dussart R., Pouvesle J. M., Kirischuk V. I., Strilchuk N. V., Mc Daniel P., and Crist C. E., *Phys. Rev. C* **61** (2000) 054305 1-7