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Acoustic Modulator for Gamma/Xray Radiation

Stanford researchers have developed a monolithic acoustic modulation platform that enables precise control of gamma-ray and X-ray nuclear resonances using surface acoustic waves (SAWs).

Current approaches for controlling nuclear resonances rely primarily on bulk piezoelectric actuators and other mechanically driven systems that offer limited modulation frequencies, reduced scalability, and less precise control. As a result, achieving high-bandwidth manipulation of nuclear resonances remains challenging.

This technology uses surface acoustic waves to generate precisely controlled mechanical vibrations that can finely tune nuclear resonance energies. By integrating acoustic control directly into the device, the platform enables higher-frequency operation and more precise control than conventional mechanical modulation methods. The technology further enables dynamic modulation of narrow nuclear resonances. The integrated design supports scalable fabrication and may facilitate the development of advanced radiation control systems for scientific, industrial, and sensing applications.

The platform provides a new method for controlling nuclear resonances and modulating radiation emission, with potential applications in high-resolution spectroscopy, synchrotron and nuclear optics, precision sensing, advanced radiation sources, and next-generation X-ray and gamma-ray technologies.

Applications

- High-resolution gamma-ray spectroscopy
- Synchrotron and nuclear optics
- Precision radiation sensing
- X-ray and gamma-ray instrumentation

- Advanced lithography systems

Advantages

- High-frequency resonance modulation
- Monolithic and scalable architecture
- Precise control of nuclear transition energies
- Compatible with microfabrication processes
- Higher bandwidth than conventional piezoelectric systems
- Enables dynamic tuning of nuclear resonances and radiation interactions

Publications

- Nazeeri, A., Brandenstein, C., Jia, C., Magrini, L., & Gratta, G.Coupling of a Nuclear Transition to a Surface Acoustic Wave. arXiv preprint arXiv:2509.02750, 2025.

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