New Tricks with an Old Rowland Circle: High Resolution X-ray Spectroscopy from the Synchrotron to the Laboratory and Back Again

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The Rowland circle concept was introduced by Henry Rowland for curved optical gratings in the 1880's and this idea was extended to X-ray wavelengths using diffractive components in the 1920's. The scientific impact of the X-ray Rowland circle has accelerated in the last 25 years due to steady improvements in optic quality and availability. There is now a proliferation of high-resolution hard X-ray Rowland spectrometers for both synchrotron light sources and laboratory-X-ray sources. The current state of this technology will be discussed in three examples.

First, I'll address the basic physics of the X-ray Rowland circle and the frequent use of large arrays of spherically bent crystal analyzers (SBCAs) at synchrotron facilities. This will include an emphasis on X-ray Raman scattering (XRS) and high-energy resolution fluorescence detection (HERFD) spectrometers.

Second, I'll summarize how my group's work on XRS spectrometers unexpectedly led to our contribution to modern laboratory-based XAFS and XES spectrometers that use SBCA. Such instruments are now in more than 150 research laboratories globally. I will include a survey of lab XAFS applications and some perspectives on the future of laboratory XAFS, especially as it relates most broadly to the XAFS community itself. For example, within a few years it may become true that the 'typical' first exposure to XAFS will happen in the lab instead of the at the synchrotron, a statement that was last true before the X-ray synchrotron era of the 1970's.

Finally, I'll present recent work on the use of asymmetric diffraction from SBCA (Gironda, Abramson, Chen, et al., 2024). Asymmetric SBCA Rowland geometries improve energy resolution and useful solid angles while also greatly expanding the useful energy range for any single SBCA. This has important consequences for lab XAFS and synchrotron XRS and may also vastly increase the operational convenience of synchrotron HERFD while simultaneously decreasing its instrumental cost.

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