

4 - 15 A Wide-band, High-resolution Vacuum Planar Crystal Spectrometer for X-ray Spectroscopy at LEAF Facility

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Hollow atoms are widely found in ion-atom collisions, synchrotron radiation experiments, electron cyclotron resonance ion sources, tokamaks, laser plasmas, and solar flares. The development of Low Energy high intensity highly charged ion Accelerator Facility (LEAF), which will provide an intense bare-ions beam up to Fe^{26+} , offers an excellent chance for the systematic research of the formation mechanisms, structure features and decay properties of hollow atoms.

In this work, a wide-band, high-resolution vacuum planar-crystal spectrometer was developed for analyzing the X-rays spectra of hollow atoms. The spectrometer was designed to cover an energy dynamic range of 0.6 to 16 keV by combining different flat crystals and an X-ray CCD detector mounted on a twistable bellows that could modulate the Bragg angles ranging from 25° to 50° . The performance of the spectrometer was evaluated in energy range of 3~12 keV by measuring the K and L X-rays generated by 10~30 keV electron beam collisions with solid titanium, silver and gold targets, respectively. The typical resolving power of the spectrometer is estimated to be around 10^3 , with a single exposure measurement range of 144~1 411 eV and corresponding energy resolution of 3.5~33.2 eV. This spectrometer could be utilized to investigate the fine hyper-satellite line structure of hollow atoms with $10 \leq Z \leq 26$.

The performance of the spectrometer in the energy range of 9~12 keV is evaluated using L diagram lines produced by 30 keV electrons collisions with gold target, as illustrated in Fig.1. The transitions are located at 9 628.05 eV ($L\alpha_2$), 9 713.44 eV ($L\alpha_1$), 11 442.45 eV ($L\beta_1$), and 11 584.75 eV ($L\beta_2$), with line widths of 22.7 eV, 23.6 eV, 24.4 eV, and 33.2 eV, respectively, corresponding to spectrometer resolving powers of 411, 424, 469, and 349. This test employed a Si (531) with $2d = 1.84 \text{ \AA}$, $L = 310 \text{ mm}$, and a slit width of 0.5 mm. The Bragg angles are 44.3° and 36.8° , which correspond to the measurements of $L\alpha$ and $L\beta$.

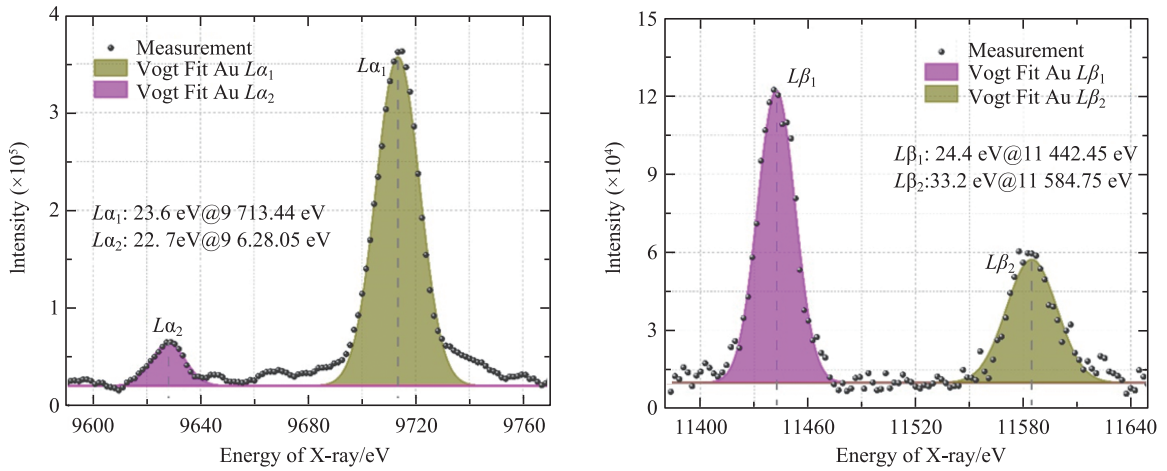


Fig. 1 (color online) Spectra of L X-rays emitted from a gold target under bombardment by 30 keV electrons. (left). $L\alpha_1$ and $L\alpha_2$ transitions are situated at 9 628.05 and 9 713.44 eV, with line widths of 22.7 and 23.6 eV. (right). $L\beta_1$ and $L\beta_2$ transitions are situated at 11 442.45 and 11 584.75 eV, respectively, with line widths of 24.4 and 33.2 eV. The theoretical energy of the L X-ray diagram lines is shown by the vertical dashed lines.