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Direct Ejecta Velocity Measurements of Tycho's Supernova Remnant

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Tycho's supernova remnant (SNR) is the remnant of SN 1572 which was recorded by Tycho Brahe. As the prototypical type Ia SNR in the Galaxy, Tycho's SNR has been well studied for investigation of the type Ia explosion mechanism. However, our understanding of the physical mechanism of such explosions is incomplete. In this talk, we present the first direct ejecta velocity measurements of the SNR. The high angular resolution X-ray imaging of Chandra allows us to reveal a patchy structure of ejecta velocities, that we cleanly separate into redshifted and blueshifted ejecta blobs for the first time. We found the typical velocities of the redshifted and blueshifted blobs are $< 7,800$ km/s and $< 5,000$ km/s, respectively. We also identified an annular region ($\sim 3.3' - 3.5'$), where the surface brightness in the Si, S, and Fe K lines reaches a peak while the line width reaches a minimum value. These minimum line widths correspond to ion temperatures of ~ 1 MeV for each of the three species. The result agrees with one-dimensional delayed detonation models for Tycho's SNR from Badenes et al. (2006).