SN 1996cr's X-ray lines at high-resolution: 
Sleuthing the Ejecta/CSM Geometry of a 30 $M_{\odot}$ SN

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SN 1996cr, located in the Circinus Galaxy, was non-detected in X-rays at ~ 2 years, yet brightened to $L_x \sim 4 \times 10^{39}$ erg/s (0.5-8 keV) after 10 years.

A 1-D hydro model of the ejecta-CSM interaction produces good agreement with the measured X-ray light curves and spectra at multiple epochs.

We conclude that SN 1996cr was most likely a massive star, $M > 30$ solar masses, which went from an RSG to a brief W-R phase before exploding within its $r \sim 0.04$ pc wind-blown shell.

Further analysis of deep Chandra HETG observations (PI Bauer, 485 ks) allows line-shape fitting of a handful of bright lines in the spectrum.

The detailed line shapes are well fit by "Polar" emission models with opening angles of ~60 (Si) and ~20 (Fe) degrees, viewed off-axis at ~55 degrees.

The higher $kT$ Fe-K emission is mostly at high latitudes; this may be the result of either lower CSM densities or higher ejecta velocities near the poles.

Similar CSM characterization may be possible around other SNe and, with higher-throughput X-ray observations, GRBs as well.