The Exceptional X-ray Evolution of SN1996cr in High Resolution

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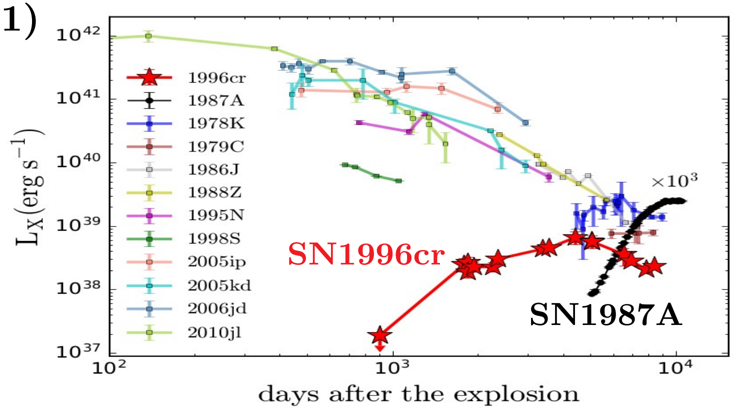
We present X-ray spectra spanning 18 years of evolution for SN1996cr, one of the five nearest SNe detected in the modern era. **HETG observations allow us to resolve spectrally the velocity profiles of emission lines and monitor their evolution as tracers of the ejecta-circumstellar medium (CSM) interaction.** To explain the diversity of observed X-ray line profiles, we explore several possible geometrical models. **We find that a polar geometry with two distinct opening angle configurations and internal obscuration can successfully reproduce all of the observed line profiles.** This poster is based on Quirola-Vásquez+, 2019, MNRAS, 490, 4536.

1)



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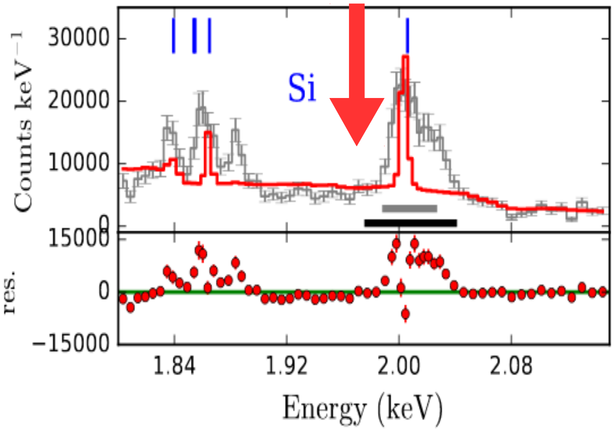

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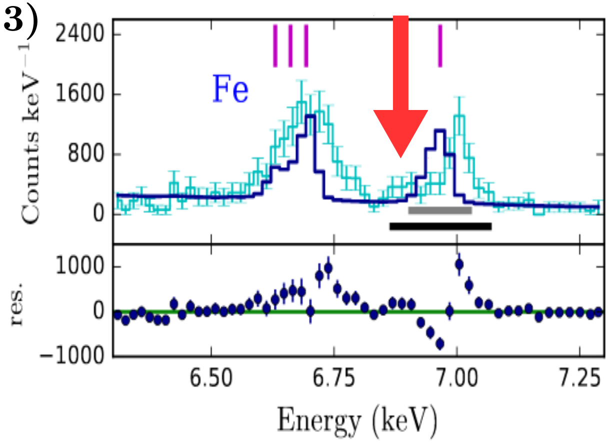
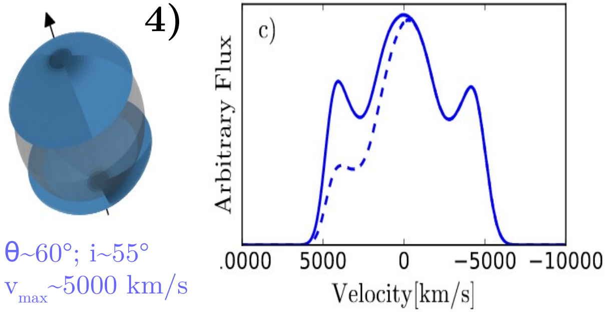


Line profile-geometry relation

4)



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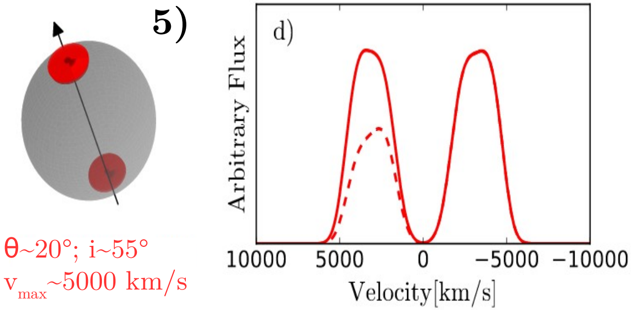


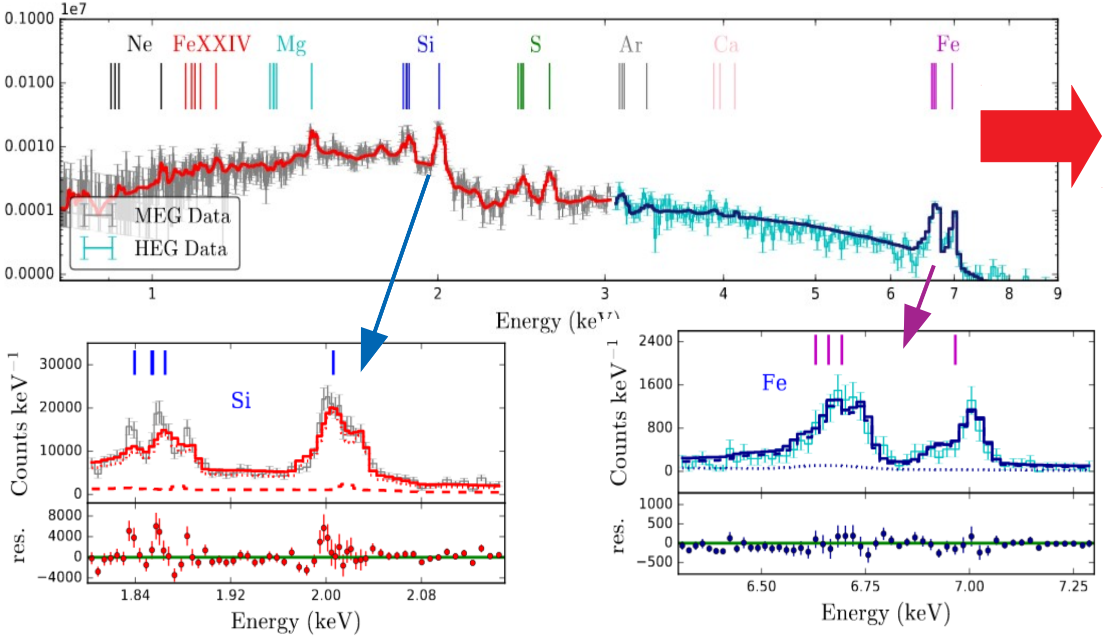
1) The nearby SN 1996cr was classified as a type IIn 11 years after the explosion. **The X-ray (and radio) luminosity exhibits an initial increase with time, similar to SN1987A (but x5 faster and 500x brighter).**

2)+3) **The broad X-ray emission lines are well-resolved and asymmetric,** providing critical insight into the kinematics of the ejecta/CSM interaction.

4)+5) **The asymmetric profiles are interpreted as a consequence of an expanding shock-interaction region** whereby the redshifted (back) side is obscured by internal dense ejecta. Imposible to fit all lines+continuum with a single thermal kinetic component.

We developed a geometrical model to explain the line-shape, as well as their asymmetry (model by an internal absorption by ejecta material). **The model is called shellblur model.**

6)



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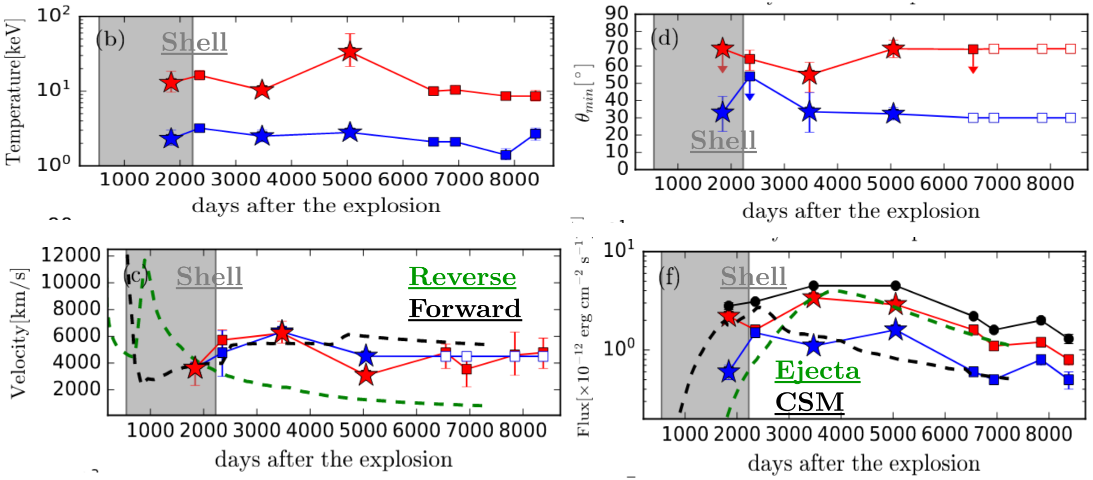

The best fit model consists of two components:

1. **C_R (high kT, high N_H and narrow polar interaction for lines >4 keV), and**
2. **C_F (low kT, low N_H and wide polar interaction for lines <4 keV).**

CONCLUSIONS

- The X-ray spectra of SN 1996cr are well explained by a bi-polar CSM-ejecta interaction model whereby the farside is obscured by dense ejecta.
- Our best explanation for the two components is that they are associated with the forward shock (C_F) and a reverse or reflected shock (C_R).
- The results are crudely consistent with the 1-D hydro model. The cause of the asymmetry of the interaction remains unclear, and could arise from the ejecta, the CSM, or both. New epochs of HETG observations required to determine which.