Spectral Analysis of Chandra data on selected regions of the Supernova Remnant Cassiopeia A

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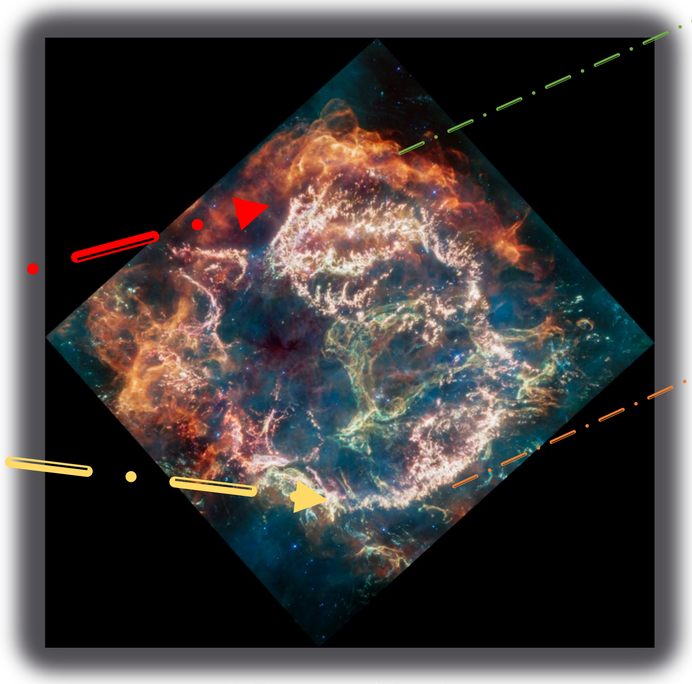
Is there shocked interstellar/circumstellar medium in Cassiopeia A?

The aim of the study is to characterize the physical and chemical observables of the thermal X-ray emitting plasma through a spatially resolved spectral analysis and to look for signatures of shocked ISM/CSM.

Inhomogeneities in the dust

Inhomogeneities in the dust distribution around Cassiopeia A.

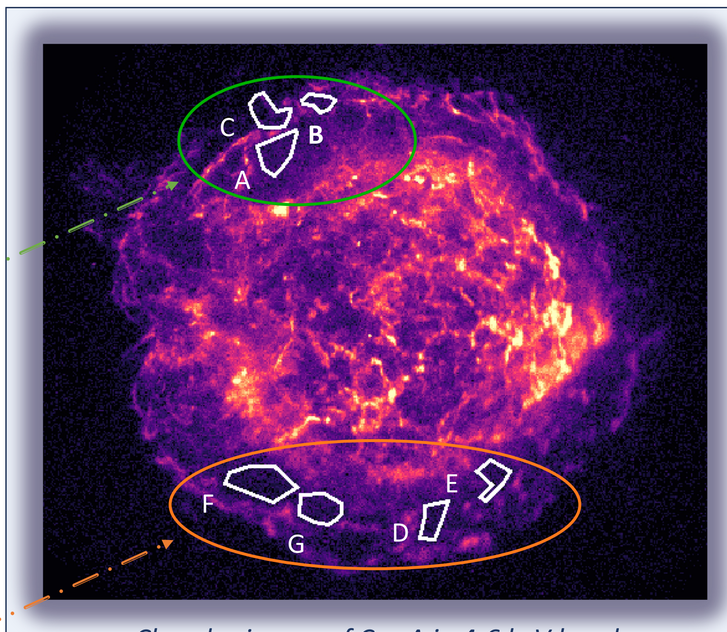
- Excess dust in the **northern** region.
- No dust in the **southern** region.



JWST image of Cas A

References:

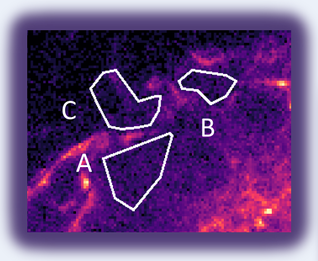
- *J. Vink, D. J. Patnaude, D. Castro, The Forward and Reverse Shock Dynamics of Cassiopeia A, The Astrophysical Journal, 2022.*
- *Milisavljevic et al., A JWST Survey of the Supernova Remnant Cassiopeia A, ApJL, 2024.*

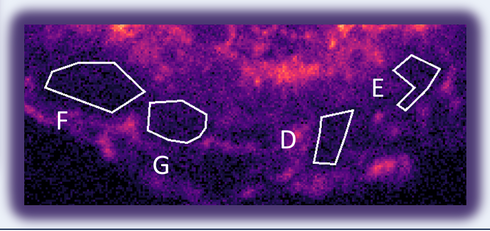


Chandra image of Cas A in 4-6 keV band

Regions in the **north-east** and **south-west** sides are selected to investigate the anisotropies on the distribution of CSM (Vink et al. 2022).

Regions selected trying to minimize the synchrotron contamination.



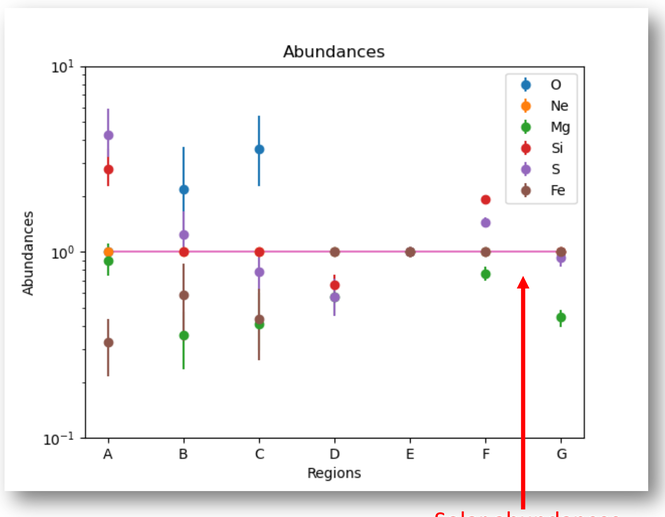


Anisotropy in the CSM density

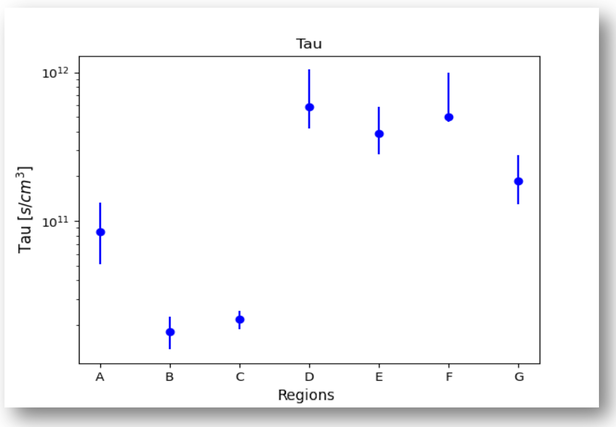
Model adopted: Tbabs*(vnei+powerlaw)

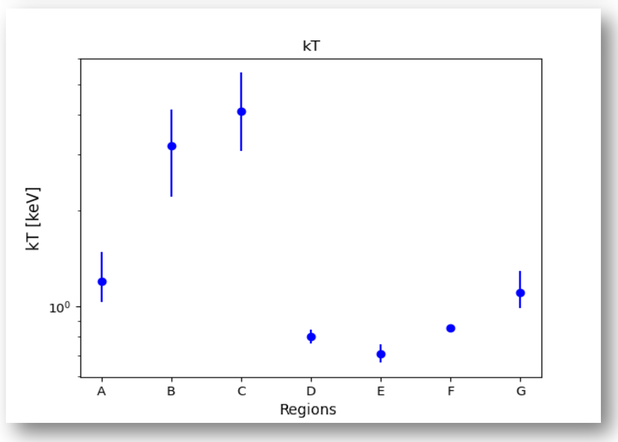
Hotter and more ionized plasma in the north-east regions due to the presence of higher velocity of the shock wave.

- Chemical abundances are close to the solar ones in all the regions but A.
- Indication of shocked ISM/CSM.
- Region A is more contaminated by the ejecta material (most inner region in the sample).



Solar abundances





References:

- *M. Miceli Eet al., XMM-Newton evidence of shocked ISM in SN 1006: indications of hadronic acceleration, Astronomy & Astrophysic, 2012.*
- S. Orlando et al., *Evidence for past interaction with an asymmetric circumstellar shell in the young SNR Cassiopeia A,* Astronomy & Astrophysics, 2022.

Electron density

Electron density in the regions estimated using two methods:

- First method

$$\mathrm{norm} = \frac{10^{-14}}{4\pi\,[D_A\,(1+z)]^2}\,n_e^2\,V_{reg}$$

which assumes $n_e = n_H$ within a volume of the region V_{reg} (Miceli et al. 2012), where D_A is the angular diameter distance to the source.

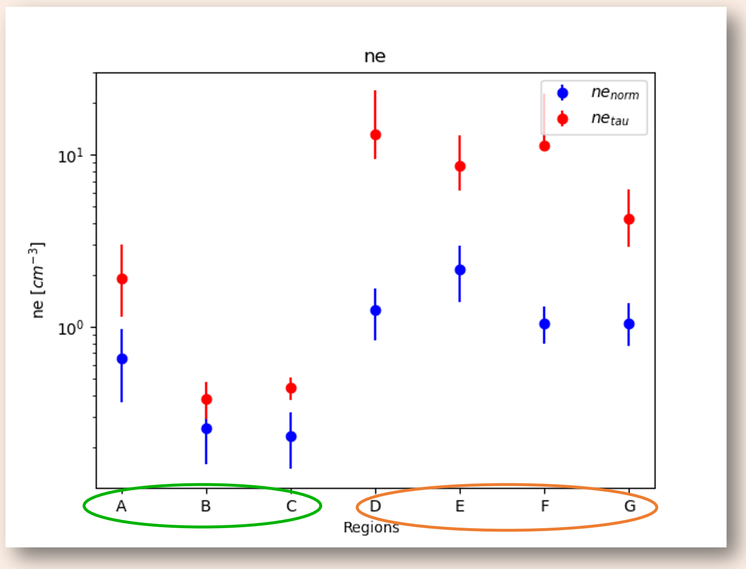
- Second method

$$v = \frac{1}{4}v_{shock} = \frac{1}{4}\frac{R_{shock}}{t_{age}}$$

$$t = \frac{R_{reg}}{v} \qquad n_e = \frac{Tau}{t}$$

$$n_e = \left(\frac{norm\;4\pi\,[D_A(1+z)]^2}{10^{-14}\,V_{reg}}\right)^{1/2}$$

Higher electron density with the second method supports that the expansion is slower in the south-west (interaction with shell by Orlando et al. 2022).



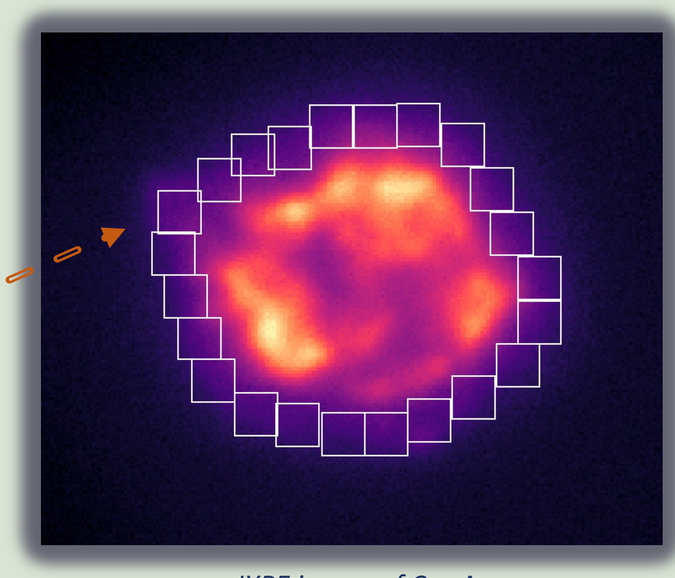
Conclusions

Roughly solar chemical abundances, indicating shocked ISM/CSM.

North-South anisotropy in the density (but not metallicity!) distribution of CSM: different shock dynamics (Vink et al. 2022).

Ongoing Investigation: Analysis of IXPE Polarimetric Data from Cas A

Spectral survey of the Cas A shell using regions of 42″×42″



IXPE image of Cas A

- Spectra of Stokes Parameters (I, Q, U).
- Energy range 3-6 keV, where spectrum is dominated by synchrotron emission.
- Fit with a power-law model and a polarization component.

Next step: including a vnei component.