

X-ray spectroscopy of SN(R) 1987A with the XMM-Newton (and Chandra) grating spectrometers



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The soft X-ray light curve





- First detection with ROSAT Linear increase of soft X-ray (0.5-2.0 keV) flux
- Chandra monitoring, XMM–observations Exponential rise

Interaction of the shock wave with the inner circum-stellar ring

• XMM-proposal for high spectral resolution monitoring

The X-ray light curve



Four 100 ks RGS spectra



Combined RGS spectra



Combined RGS spectra



Empirical model to characterise emission lines



<u>The data:</u> LETG-ACIS-S 2004 (+1/–1) HETG-ACIS-S 2007 (MEG +1/–1) LETG-ACIS-S 2007 (+1/–1) RGS1/2 EPIC-pn 2003 RGS1/2 EPIC-pn 2007 RGS1/2 EPIC-pn 2008 RGS1/2 EPIC-pn 2009

Model:

continuum 2 brems with absorption nearly 50 Gaussian lines

Combined fit to 18 spectra: constant factor for simultaneous spectra line energies linked line widths linked close lines: relative energies linked line widths linked line widths linked line widths include kinematic and geometrical effects seen in the Chandra spectra absorption parameters linked

Line shifts



He-like line triplets



Evolution of line fluxes and ratios



Evolution of line fluxes and ratios



In collisional ionisation equilibrium: G=(f+i)/r and r/Lyα are expected to decrease with increasing kT NEI !

The VPSHOCK model



<u>The data:</u> RGS1/2 EPIC-pn 2003 RGS1/2 EPIC-pn 2007 RGS1/2 EPIC-pn 2008 RGS1/2 EPIC-pn 2009

Model: 2 vpshock with absorption

combined fit to 12 spectra: constant factor for simultaneous spectra same absorption same elemental abundances (some abundances fixed) same ionisation timescales

Temperature evolution



Significant increase of kT in both vpshock components !

More on the Ne triplet



The vpshock model does not reproduce the Ne-triplet very well !

Conclusions

• The soft X-ray light curve of SNR 1987A still rises exponentially but slower !

RGS spectra show changes in emission line ratios
Non-Equilibrium Ionisation

• VPSHOCK model indicates temperature increases in both low-kT (since 2003) and high-kT (at least since 2007) components

• A lot of work still needs to be done ! Ne triplet: additional emission lines of Fe? Modelling with continuous kT distribution Line broadening in vpshock model to include Chandra spectra