η Carinae: Variability in a New Light

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Abstract. Recent *ROSAT* Position Sensitive Proportional Counter (PSPC) observations for the first time unequivocally reveal the presence of a compact source of hard X-ray emission centered on the peculiar star η Carinae. These observations also show a dramatic change in the hard-band ($E \geq 1.6$ keV) counting rate by $\approx$ a factor of 2 in a 4-month interval. *ROSAT* High Resolution Imager (HRI) observations which span the PSPC observations also reveal a variable source of X-ray emission centered on η Carinae. Thus strong variability which is a characteristic of η Carinae in radio through IR and visible-band wavelengths is also observed at X-ray energies. We examine the X-ray lightcurve of η Carinae using available EINSTEIN, *ROSAT* and *ASCA* data.

1. Introduction

η Carinae is perhaps the most massive star in the Galaxy. The star is violently unstable and is most renowned for an eruptive event which took place in the mid-19th century, at which time the star ejected nearly 1 solar mass into space.

η Car is a known X-ray emitter in the range 0.1–10 keV. Previous *EINSTEIN* observations (Seward et al. 1979, Chlebowski et al. 1984) discovered diffuse emission around η Car along with unresolved emission from a point source centered on η Car. The *EINSTEIN* observations suggested that the unresolved emission was significantly harder than the resolved emission. *ROSAT* PSPC (Corcoran et al. 1995) observations obtained in the 1992–1993 interval imaged the soft diffuse X-ray "shell" and confirmed the hard nature of the point-like source centered on η Carinae. These PSPC observations also discovered a nearly fourfold increase in the X-ray luminosity of the hard unresolved source.

In this paper we present unpublished *ROSAT* HRI data which confirm and extend the variability of the unresolved source. We use *EINSTEIN* IPC, *ROSAT* PSPC and HRI, and archival *ASCA* data to construct an X-ray lightcurve of η Car. This lightcurve suggests that the X-ray outburst occurred near Jun 1992 and continued through 1993. The source seems to be declining in brightness but had not reached pre-outburst levels by Jun 1994.

2. *ROSAT* HRI Observations of η Car

ROSAT observed η Carinae for 50 ksec with the HRI. The observation was obtained in Jun 1992 (11 ksec) and Jun 1994 (40 ksec). Figures 1 and 2 show the exposure-corrected images from these 2 time intervals. In each case a bright diffuse shell of emission roughly centered on η Car can be seen. The morphology of this shell is similar to that mapped out by the *EINSTEIN* HRI. Comparison of Fig. 1 and Fig. 2 clearly shows a point source visible in the Jun 1994 observation which was not detected in the Jun 1992 observation. This point source is consistent with the optical location of η Car and with the location of the unresolved hard source detected by Corcoran et al.

3. The X-ray "Lightcurve"

Figure 3 shows the X-ray "lightcurve" of η Car derived using *EINSTEIN* IPC, *ROSAT* PSPC and HRI data as well as an archival *ASCA* PV-phase observation (Tsuboi, Koyama and Petre 1996). Fluxes were directly determined from the PSPC and *ASCA* data by spectral fitting, and converted to luminosities using an assumed distance of 2600 pc. HRI count rates were converted to luminosity using a flux conversion factor derived by comparison of the observed HRI count rate to the flux derived from the PSPC spectra for the Jun 1992 HRI and PSPC observations. The lightcurve suggests the X-ray luminosity of η Car in mid-1992 was near the value observed by the IPC in 1978. By early Jan 1993 the X-ray luminosity had increased, with the brightness peak occurring near the time of the *ASCA* observation in Aug 1993. By Jun 1994 the X-ray emission was on the decline, though it the star was still significantly brighter than in Jun 1992.

4. Discussion

It was suggested by Chlebowski et al. that the point-like hard emission component was produced by the collision of a fast-moving stellar wind from the star with thick dust shells close to η Car. If this is the case then the X-ray luminosity of the hard source is a measure of the mass-loss rate from the star, and the observed variability suggests the occurence of an epoch of increased mass-loss from the star. The X-ray observations leave no doubt that a fundamental change in the star has occurred.

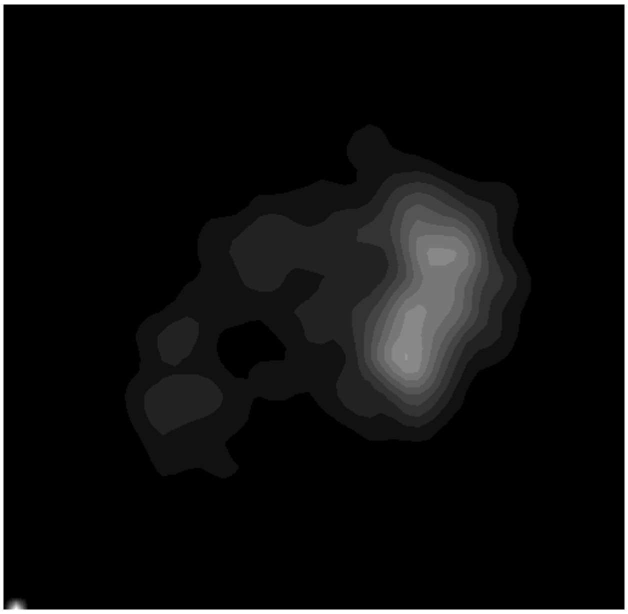

Fig. 1. HRI X-ray map centered on η Car, Jun 1992. N is to the top, E to the left. Region shown is approximately 2 arcmin $\times$ 2 arcmin.

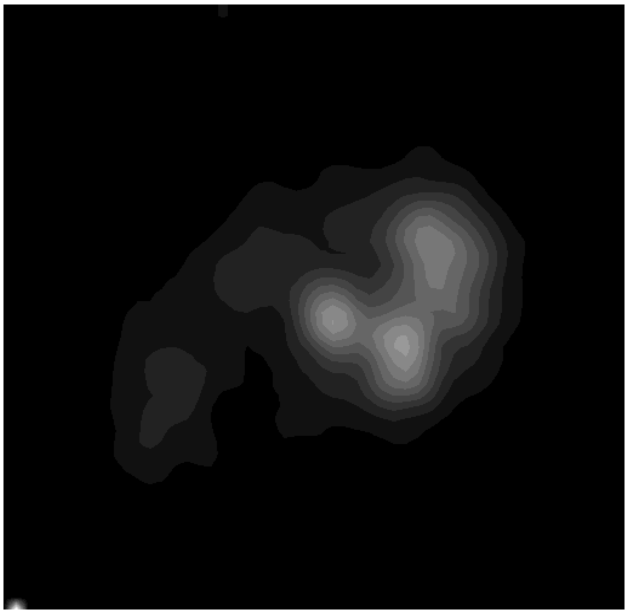

Fig. 2. HRI X-ray map of η Car, Jun 1994. Note the appearance of a point source at the center of the diffuse X-ray shell.

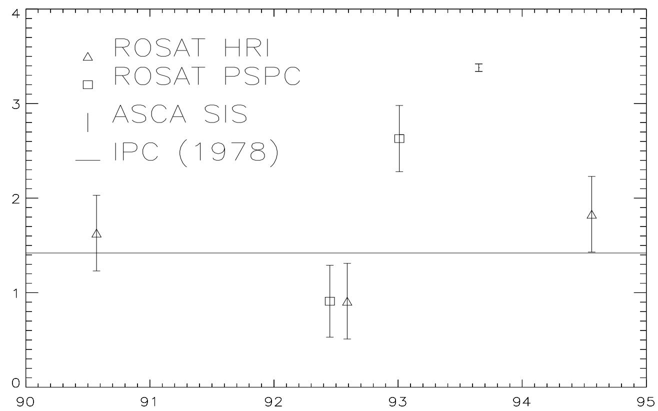

Fig. 3. X-ray "lightcurve" of η Car, 1978–1994

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