NUV and FUV Spectroscopic Timing Observations of the Crab Pulsar with HST/STIS

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Spectroscopic ultraviolet observations of the Crab Nebula and its pulsar were accomplished using the Space Telescope Imaging Spectrograph (STIS) on the Hubble Space Telescope (HST). As the Multianode Microchannel Array (MAMA) detectors were used in time-tag mode, good time resolution (0.125 microseconds) and good spatial resolution (0.0244 $''$pixel^{-1} were obtained. The low dispersion grating modes G140L and G230L provided spectral resolving power of 600 from 1140 to 3200 Å [1,3]. Results are already published by Gull *et al.* (1998) for the NUV spectral region and by Sollerman *et al.* (2000) for the FUV spectral region and for combined spectroscopy for the NUV, FUV and visible spectrum recorded from the Nordic Optical Telescope.

The spectroscopy of the Pulsar is consistent with a flat spectrum dereddened with a standard extinction curve with the parameters $E(B-V) = 0.52$, $R = 3.1$. This dereddened spectrum of the Crab pulsar can be fitted by a power law with spectral index $\alpha_\nu = 0.11 \pm 0.04$. The main uncertainty in determining the spectral index is the amount and characteristics of the interstellar reddening, and we have investigated the dependence of α_ν on E(B-V) and R. The Ly α absorption indicates a column density of $(3.0 \pm 0.5) \times 10^{21}$ cm^{-2} of neutral hydrogen, which agrees well with our estimate of E(B-V)=0.52 mag. Other lines show no evidence of severe depletion of metals in atomic gas. Broad, blueshifted absorption is seen in C IV (1550Å), reaching a blueward velocity of 2500 km s^{-1}. While the high velocity absorption may be internal to the nebulosity, it is more likely from a fast outer shell surrounding the Crab Nebula, pre-existing from the progenitor wind phase.We adopt a spherically symmetric model for such a shell. From the line profile we find that the density appears to decrease outwardly. A likely lower limit to the shell mass is 0.3 $M_\odot$ with an accompanying kinetic energy of $\sim 1.5 \times 10^{49}$ ergs. A fast, massive shell with 10^{51} ergs cannot be excluded but is less likely if the density profile is much steeper than $\rho(R) \sim R^{-4}$ and the maximum velocity is < 6000 km s^{-1}.

With the time-tag mode of the MAMAs, we obtained the pulse profile in the spectral region from 1140 to 3200 Å. The profile is marginally narrower in the FUV relative to the profile obtained in the NUV, and at visible wavelengths [2]. In the extended emission covered by our $25'' \times 0.5''$ slit in the far-UV, we detect C IV 1550 Å and He II 1640 Å emission lines from the Crab Nebula.

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