The Origin of Soft X-rays in DQ Herculis
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ABSTRACT: DQ Herculis (Nova Herculis 1934) is a deeply eclipsing cataclysmic variable containing a magnetic white dwarf primary. The spin of the white dwarf is indirectly detected in the optical as a 71± oscillation, which is believed to be due to precessing in the accretion disk of X-ray and EUV radiations from the poles. The accretion disk is thought to block the line of sight to the white dwarf at all orbital phases. Nevertheless, soft X-rays have been detected from DQ Her with ROSAT PSPC. We present preliminary results of our Chandra ACIS imaging observations of DQ Her, confirming the ROSAT detection. The X-ray source is point-like, and exhibits a shallow partial eclipse.

1. DQ Herculis
The 1934 classical nova eruption of DQ Her reached m_v ~ 1.3 and was observed in intricate detail (see Martin 1989 for a review). The expansion parallax method places this system at an estimated distance of 561 ± 19 pc (Herbig & Skrutskie 1992). When Walker (1956) discovered that DQ Her was an eclipsing system with an orbital period of 4.65 hr, this led to a series of studies over the subsequent decades, establishing CVs to be short-period, interacting binaries with a white dwarf and a relatively normal star. Walker (1956) also discovered the coherent 71 sec photometric oscillation: we now understand that DQ Her contains a magnetic white dwarf, accreting onto the magnetic polar regions which are offset from the rotational poles, i.e., an oblique rotator. About 20 X-ray bright (>10^{32} ergs s^{-1}) in 2-10 keV) CVs with coherent periodicities have been discovered since the late 1970s, and are classified as intermediate polar (IPs) or DQ Her stars (Patterson 1994). However, the prototype DQ Her was not detected in the Einstein IPC observation with a 2σ upper limit of 0.0046 cts s^{-1} (Cordova et al. 1981), or roughly 3 x 10^{30} ergs s^{-1}.

3. Observations
Chandra ACIS-S observations were performed from 2001 July 26 13:00 UT to July 27 02:31 UT, and again from 2001 July 29 17:00 UT to July 30 02:27 UT, for a total of ~69 hours (the gap was to accommodate a TOO observation of WZ Sge). We have extracted images, spectra, and light curves from these observations individually, before combining the results. Source spectra and light curves were extracted from an arcsec radius region; background was extracted from an annulus of 20 arcsec outer radius and 10 arcsec inner radius centered on the source. The source was detected at 0.055 cts s^{-1} (~3 x 10^{30} ergs s^{-1}), while background (scaled by the areas of the extraction region) is estimated to be 8.2 x 10^{34} cts s^{-1}.

4. Imaging Characteristics
As shown in Figure 1 above, DQ Her is strongly detected at the optical position with an accuracy of ~1 arcsec. Our preliminary analysis indicates that observed profile of the source is consistent with the point spread function of Chandra ACIS-S. Any nebular contribution, such as that seen around GK Per (Nova Persei 1981; Balman 2001), must contribute only a small fraction of the observed X-rays. At the distance of DQ Her, 1 arcsec corresponds to 560 AU, or 8.4 x 10^{14} cm; most of the X-rays originate within this distance from the central binary, whereas the optical shell extends to ~10 arcsec. Any successful model must be able to explain the different X-ray behaviors of the DQ Her and GK Per ejecta.

5. Spectroscopic Characteristics
We have attempted single component fits to the ACIS-S spectrum of DQ Her using power-law, bremsstrahlung, blackbody, and metallic (thermal plasma) models; none of these are successful. The best successful representation (\chi^2 = 1.25; see Figure 2) is a two-component model consisting of K/T = 0.63 keV metallic plasma model plus a power-law photon index -2. Although emission lines do exist in the X-ray spectrum of DQ Her, they are weaker than predicted by single-temperature plasma models; the continuum also extends to higher energies than in plasma models. Future development in the theories of nebular or wind-scattered X-rays are necessary for an understanding of DQ Her’s X-ray spectrum.

References
Martin, P.G. 1989, in “Classical Novae.”