The Chandra View of the weak-lined T Tau binary HDE 245059

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Abstract

We present the Chandra High-Energy Transmission Grating Spectrometer (HETGS) observation of HDE 245059. Our target is a young weak-lined T Tauri star (WTTS), member of the pre-main sequence group near λ Orionis (d~450 pc). HDE 245059 is among the brightest WTTS in the X-ray domain (log L_X~32 erg s^{-1}); previous ROSAT and ASCA observations showed a typical plasma temperature of 6-8 MK. Our high spatial resolution near-infrared observations with Keck indicate that HDE 245059 is in fact a binary separated by 0.87", probably both components being WTTS based on their color indices. We detected both components of the binary in the zeroth order Chandra image and in the grating spectra. The lightcurves show X-ray variability of both sources and in particular a flaring event with a significant hardening of the hardness ratio in the weaker southern component. The spectra of both stars are similar; they show a combination of cool and hot plasma as demonstrated from the presence of several iron lines from Fe XVII to Fe XXV and a strong bremsstrahlung continuum at short wavelengths. We have extracted the combined zeroth order and grating spectra for the binary. We fitted them simultaneously in XSPEC with a 4-T collisional plasma in order to get emission measure distribution and chemical abundances.

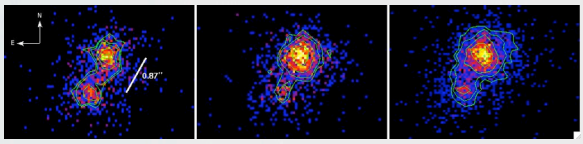
HDE 245059

spectral type	K1
age (Myr)	1 - 4
distance (pc)	450

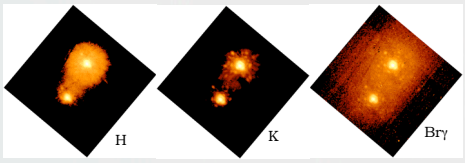
Observation Log Summary

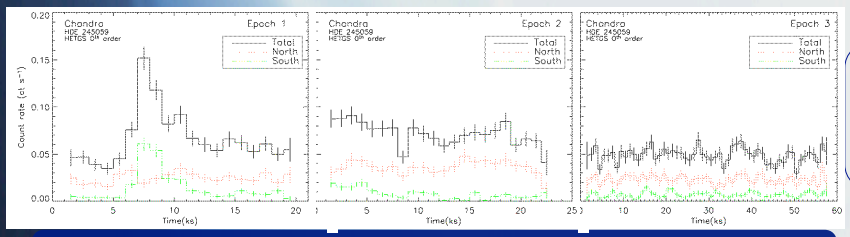
epoch 1	12/30/2005
epoch 2	01/07/2006
epoch 3	01/13/2006
observing time (ks)	93

Average Chandra ACIS images of the HDE 245059 binary for the three different epochs, after applying subpixel event position corrections (see Kastner et al. 2002, ApJ, 581, 1225). The binary separation is about 0.87" with a position angle of 150 degrees.



Near-infrared Keck adaptive optics images of HDE 245059 in the H, K, and Brγ (2.166 microns) filters. The separation of the binary is 0.871" ± 0.004" with a position angle of 150.1 ± 1.0 degrees. The magnitude differences between the two components are 1.00 ± 0.09 mag in H, 0.91 ± 0.07 mag in K, and 0.90 ± 0.10 mag in Brγ. The magnitude differences suggest that both components have similar colors. North is toward the top.



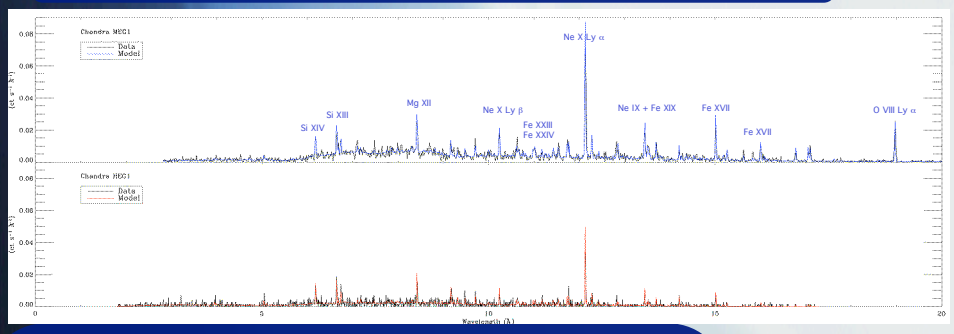


Zeroth order light curves for the northern component (red), the southern component (blue), and the total emission (black) from the binary. The extraction radius for each component is 0.4", whereas we used 2" for the sum. A flare from the southern component is visible during the first epoch observation.

We performed several fits using a collisional plasma model (VAPEC) that includes several isothermal components, combined with a photoelectric absorption model (WABS) using the zeroth order spectrum together with the grating HEG1 and MEG1 spectra. The results from the best-fit model, a 4-temperature plasma, are displayed in the table. Abundances are given with respect to solar photospheric values (Grevesse & Sauval 1998).

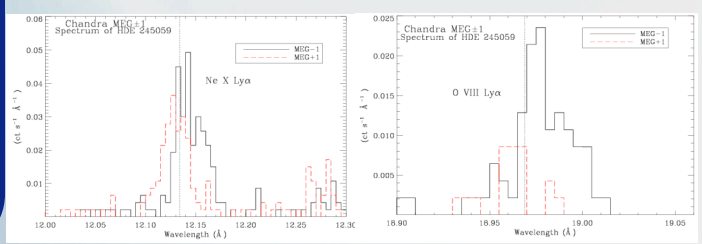
Free parameters for the best-fit model.

Parameter	Value	Parameter	Value
T_1 (MK)	3.8 $^{+0.3}_{-0.5}$	O	0.31 $^{+0.05}_{-0.06}$
T_2 (MK)	8.1 $^{+0.2}_{-0.5}$	Ne	0.74 $^{+0.06}_{-0.01}$
T_3 (MK)	15.4 $^{+1.6}_{-0.7}$	Mg	0.21 $^{+0.02}_{-0.03}$
T_4 (MK)	52.4 $^{+6.2}_{-6.2}$	Al	0.32 $^{+0.2}_{-0.2}$
EM_1 (10^{54}cm^{-3})	1.19 $^{+1.1}_{-1.5}$	Si	0.20 $^{+0.02}_{-0.03}$
EM_2 (10^{54}cm^{-3})	2.92 $^{+0.5}_{-0.3}$	S	0.19 $^{+0.05}_{-0.05}$
EM_3 (10^{54}cm^{-3})	2.69 $^{+0.6}_{-0.24}$	Ar	0.67 $^{+0.4}_{-0.4}$
EM_4 (10^{54}cm^{-3})	1.02 $^{+0.1}_{-0.6}$	Ca	0.65 $^{+0.5}_{-0.4}$
N_H(cm^{-2})	< 4.1· 10^{19}	Fe	0.27 $^{+0.01}_{-0.04}$
		Ni	=Fe



Chandra HEG and MEG spectra (black) with the 4-T plasma model overlaid (blue and red respectively). The ±1 order spectra were summed together to increase the signal-to-noise. The grating spectra of the binary components show similar features, a combination of cool and hot plasma confirmed by the presence of several iron lines from Fe XVII to Fe XXV. The strongest line is Ne X Ly α (12.13 Å). The lower fluxes from Fe lines (e.g., Fe XVII at 15 and 17 Å) indicate a high Ne/Fe ratio, suggesting an inverse FIP effect, as confirmed from the best-fit model (see Table). High continuum due to bremsstrahlung is visible at short wavelengths is consistent with hot plasma, detected by Fe lines at high ionization states (XXI-XXIV). Ne IX lines, typical of cool plasma, are well detected with no evidence for high density (> 10^{12} cm^{-3}). Major emission lines are labeled. At full resolution the HETGS spectra show emission lines from each component of the binary, as shown in the figure on the right for Ne X and O VIII.

MEG full resolution spectra for the binary HDE 245059. The rest wavelength is shown by a straight line. To extract the spectra the Northern star was chosen as origin of the wavelength system.



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