Time resolved X-ray spectral analysis of class II YSOs in NGC 2264 during optical dips and bursts

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Introduction

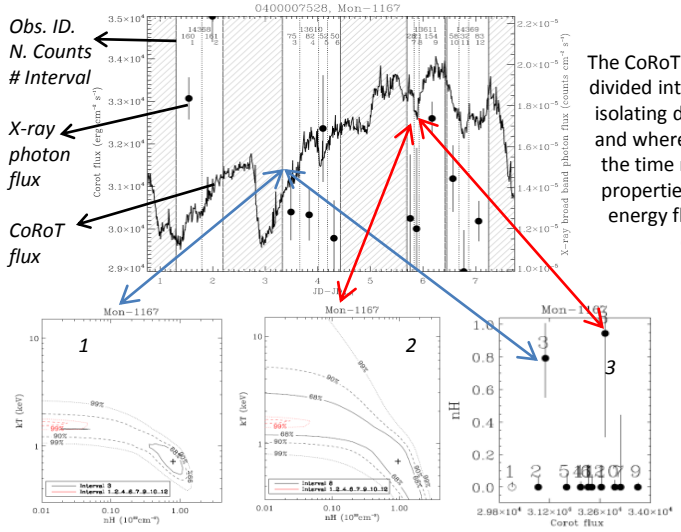
The Coordinated Synoptic Investigation of NGC 2264 (Cody et al. 2014; Stauffer et al. 2014) is an unprecedented project involving 15 space and ground telescopes, some of which observed NGC 2264 simultaneously, aimed at studying the time variability of young (1-5 Myrs) stars. We present the analysis of simultaneous optical (CoRoT) and X-ray (Chandra/ACIS-I) observations of 74 stars with disks.

Analysis of the simultaneous CoRoT and ACIS data

We present the first time resolved spectral analysis of stars with disks, using the optical light curve to isolate events such as optical dips due to variable extinction and bursts due to unsteady accretion. CoRoT light curves are cleaned following the standard reduction pipeline. ACIS events are extracted with ACIS Extract *(Broos et al. 2010)*; spectral analysis is performed with Xspec v.12.8.1 *(Arnaud 1996)*.

Increasing X-ray absorption during optical dips

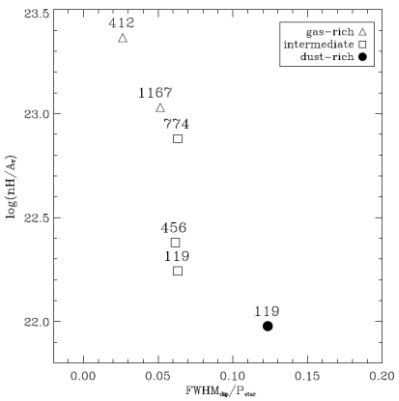
In 9/33 stars with variable extinction we observe increasing X-ray absorption during the optical dips, indicating that the circumstellar material is absorbing both the photospheric and the coronal emission.



The CoRoT light curves are divided into time intervals isolating dips and bursts, and where we estimated the time resolved X-ray properties (photon and energy fluxes, NH, kT, etc..)

Mon-1167 is an example of star with increasing X-ray absorption during the optical dip. In #3 N_H is larger than other intervals at >68% confidence (1, 3); in #8 N_H is the largest from the best fit (3) but solutions with N_H=0 are possible within 68% confidence (2).

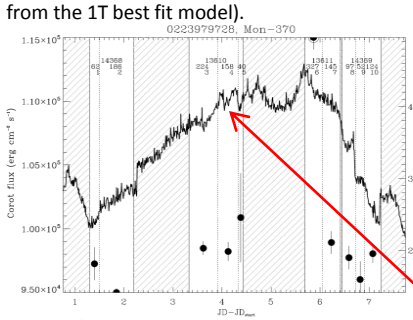
Star	Interval	ΔF_{CoRoT}	ΔAv	ΔnH_{dip}	nH_{over}	nH/Av	$FWHM_{dip}$	P_{star}	$FWHM_{dip}/P_{star}$
MON-name		%	mag	$10^{22}cm^{-2}$	$10^{22}cm^{-2}$	$10^{22}cm^{-2}mag^{-1}$	days	days	
119	4	8.9	0.12	$0.21^{0.44}_{0.03}$	$0^{0.03}$	1.75	0.2	3.3	0.06
119	6	15.7	0.22	$0.21^{0.44}_{0.03}$	$0^{0.03}$	0.95	0.4	3.3	0.12
412	6	3.5	0.05	$1.20^{1.88}_{0.71}$	$0.04^{0.12}$	23.2	0.2	6.8	0.03
456	6	15.2	0.21	$0.51^{0.71}_{0.33}$	$0^{0.03}$	2.4	0.3	5.1	0.06
774	5	5.7	0.08	$1.07^{1.26}_{0.88}$	$0.54^{0.79}_{0.30}$	7.57	0.2	3.5	0.06
1076	2	10.65	0.15	$1.67^{2.16}_{1.16}$	$0^{0.01}$	11.4	2.7		
1167	3	5.5	0.07	$0.79^{1.01}_{0.55}$	$0^{0.06}$	10.7	0.5	8.8	0.05



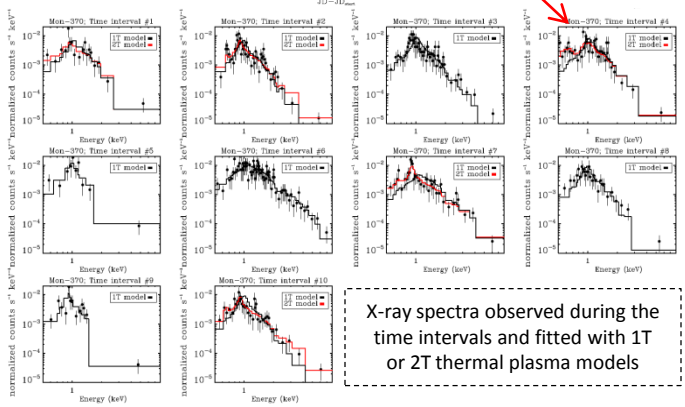
In 7 dips we calculate: $N_{H(dip)}$ in excess with respect the average spectrum; $A_{V(dip)}$ from the decrease of CoRoT flux, and then $N_{H(dip)}/A_{V(dip)}$. In this way, we infer the composition of the obscuring material, being not dust-rich in 6/7 dips, and with $FWHM_{dip}/P_{star} < 0.2$ which is typical of occultations by accretion streams *(Stauffer et al. 2015)*

Soft X-ray emission during the optical bursts

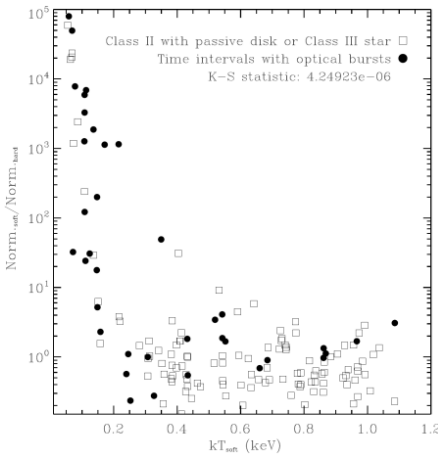
In 5/27 stars with optical bursts the X-ray spectrum during the bursts shows an evident soft X-ray spectral component (e.g. the fit with 1T thermal plasma model is not good and the emission below 1 keV is larger than the prediction from the 1T best fit model).



Soft X-ray spectral component in #4 and #7. Evident bursts in #4.



X-ray spectra observed during the time intervals and fitted with 1T or 2T thermal plasma models



We fit the spectra of not accreting stars and those observed during the optical bursts with 2T thermal plasma model and calculate the ratio of the soft and hard normalizations

We find evidence for larger cold plasma emission measure and softer spectra observed during the optical bursts than in not accreting stars