Photometric activity of the EXORs type stars in the near infrared wavelengths

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Abstract

A study of the relationship between the observed IR characteristics of EXors type variables and the mechanisms operating during their typical evolutionary phase pre-main sequence is presented. The results were obtained mainly from observations in the near infrared region of the spectrum on the telescope AZT-24 in Italy in conjunction with astronomers of the Roman astronomical Observatory. We analyze the data obtained during long monitoring program EXORCISM and published data. The photometric and spectral variability of a number of objects agrees well with the assumption of the role of disk accretion as the main driver of the variability of EXors.

EXors

EXors are pre-main sequence eruptive stars showing intermittent outbursts (Δmag about 4-5) of short duration (months) superposed on longer (years) quiescence periods. **These bursts**, usually detected in the optical and near-IR bands, **are related to disk accretion events** in which there is a sudden increase of the mass accretion rate by orders of magnitude (e.g. Hartmann & Kenyon 1985).

No detailed analysis or modeling of EXor inner disk structure is available, so **the mechanism regulating the outbursts is basically not known**. Reasons are:

i) lack of long-term multi-wavelength monitoring programs of photometric and spectroscopic properties;

ii) only a few studies were able to compare photometry and/or spectroscopy of the outburst and quiescence phase (e.g. Lorenzetti+ 2009, Sipos+ 2009, Audard+ 2010, Sicilia-Aguilar+ 2012, Juhasz+ 2012);

iii) absence of high angular resolution observations able to spatially resolve the inner disk of the sources.

Source	L_{bol} ($L_\odot$)	max-min (V mag)	A_V (mag)	Id.
Classical EXors (as defined by Herbig 1989)				
UZ Tau E	1.7	11.7 – 15.0	1.5	a
VY Tau	0.7	9.0 – 15.3	0.8	b
DR Tau	1.0 - 5.0	10.5 – 16.0	1.7 – 2.0	c
V1118 Ori	1.4 - 25	12.8 – 17.5	0 - 2	d
NY Ori	…	14.5 – 17.5	0.3	e
V1143 Ori	…	13 - 19	…	f
EX Lup	0.7	8.4 – 13.2	0	g
PV Cep	100	14.6 – 18.0	5 - 7	h
Recently identified (and more embedded) candidate EXors				
V1180 Cas	0.07	15.7 - >21	4.3	A
V512 Per	…	15.9 – 19.0	6 - 15	B
LDN1415	…	14.7 – 18.4	…	C
V2775 Ori	1.9 - 22	11.8 – 16.4	18	D
V1647 Ori	5.2, 2.8-44	14.4 – 20.3	9 - 19	E
GM Cha	1.5	10.6 – 12.7	13	F
OO Ser	4.5 - 26/36	11.4 – 16.1	42	G
V2492 Cyg	20	14.7 – 18/19	6 - 12	H
V2493 Cyg	2.7 - 12	13.6 – 17.0	3.4	I
GM Cep	30/40	12.4 – 14.6	2 - 4	J

2. Project

EXORCISM is a systematic monitoring project we have just started, based on **photometric and spectroscopic observations** at optical and near-IR wavelengths, with the aim to:

→ trace **photometric variations** (monthly basis) → **prompt detection of any possible outburst**

→ trace **spectroscopic variations** (yearly basis, more often in case of outburst)

The goals of this part of the program are:

→ modelling of the magnetospheric region and inner/outer disk structure both in quiescence and outburst → trace **structure variations**

→ study outburst **trigger mechanism**

3. Facilities

Systematic monitoring

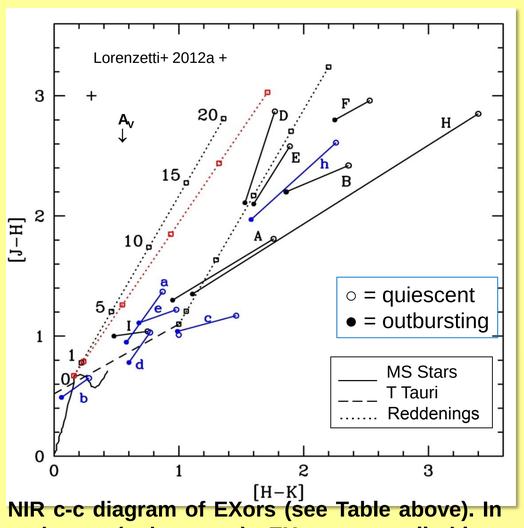
- AZT24 1m – Campo Imperatore (Italy): ***J H K Imaging + spectroscopy*** *(R ~ 250)*
- TNG (Telescopio Nazionale Galileo) 3.6m – Canary Islands: ***B V R I J H K Imaging + spectroscopy*** *(R ~ 1500)*
- REM (Robotic Telescope) 0.6m – ESO La Silla (Chile): ***B V R I J H K Imaging***
- LX200 0.4m – St. Petersbourg University (Russia): ***U B V (Johnson) R I (Cousin) imaging + polarimetry***.

Interferometry

- VLTI AMBER+MIDI – ESO Paranal (Chile) – ***H K spectro-interferometry*** *(R ~ 1500)* + ***N spectro-interferometry*** *(R ~ 30)*
- CHARA CLIMB – MWO (California) – ***H K interferometry***

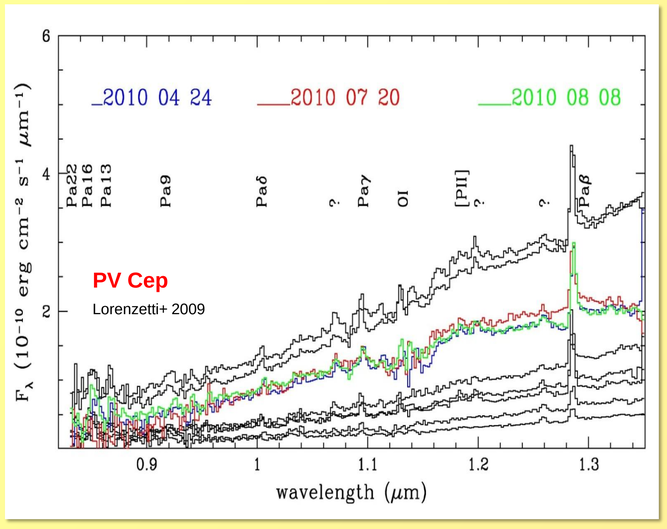
4. Our previous results

Data collected by EXORCISM will alllow us to replicate in a systematic and more detailed fashion the investigations performed by our group during the last few years on some EXor objects, here summarized.



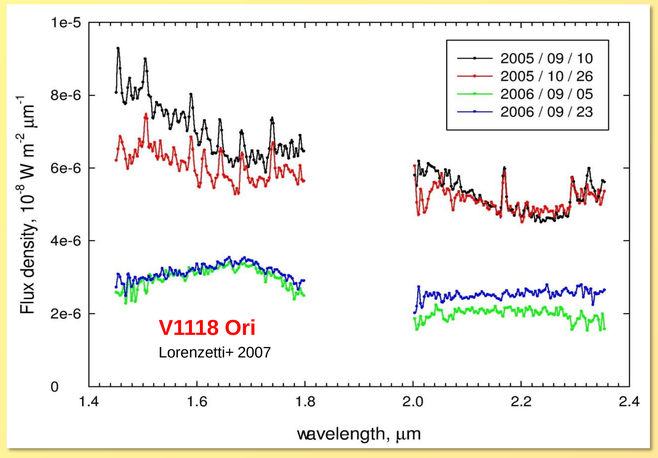
NIR c-c diagram of EXors (see Table above). In outburst (quiescence) EXors are all bluer (redder).

⇒ **typical variations tend not to follow the extinction vector, so other effects have a role (e.g. disk stratification temperature).**



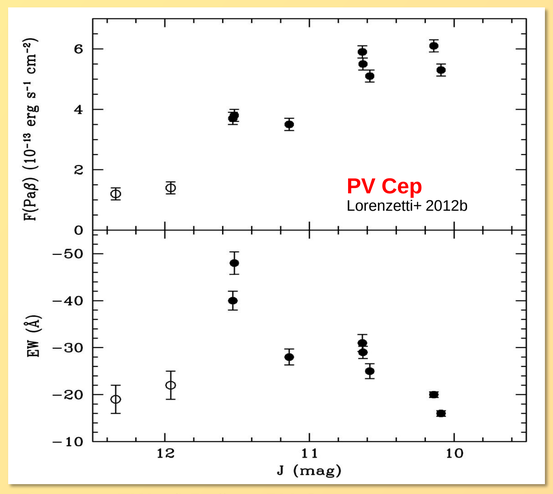
Low resolution (R ~ 250) spectroscopic monitoring of PV Cep in the NIR (0.8 - 2.5μm).

⇒ **EXors spectra show a wide variety of emission features dominated by HI recombination lines.**



As continuum fades (and reddens) the spectrum tends to become featureless (Brγ fades by more than a factor of 6): presence of features and continuum excess seem to be correlated.

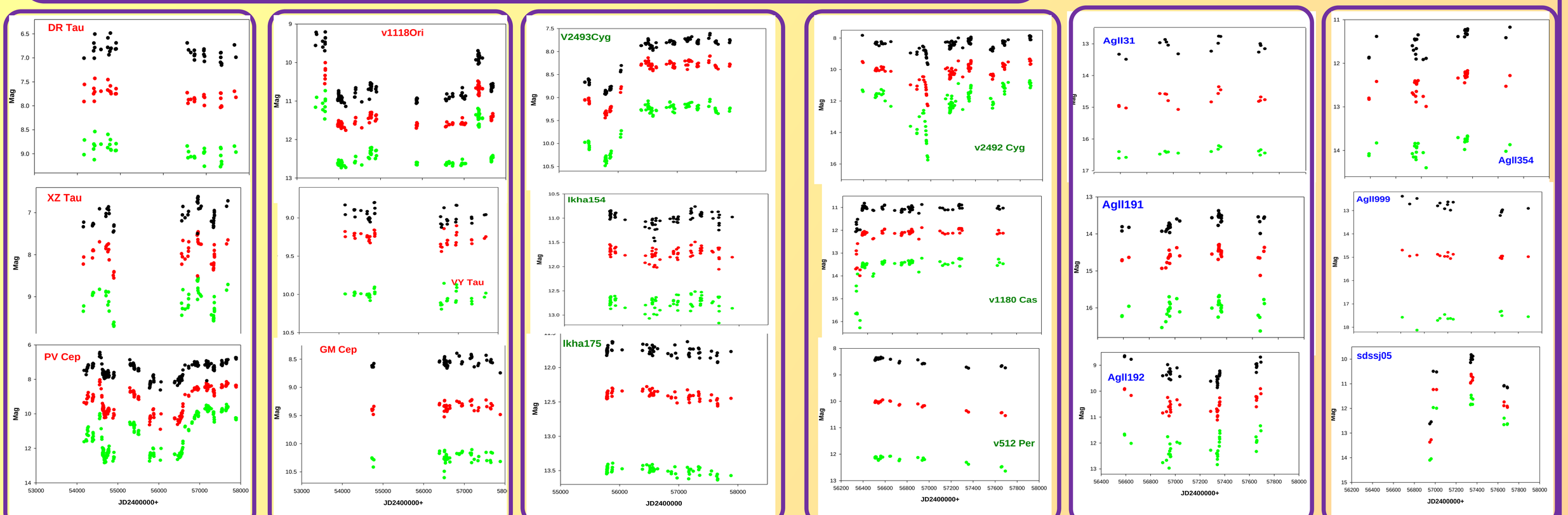
⇒ **correlation: emission lines are generated by some mechanism strongly related to the accretion onto the central source**

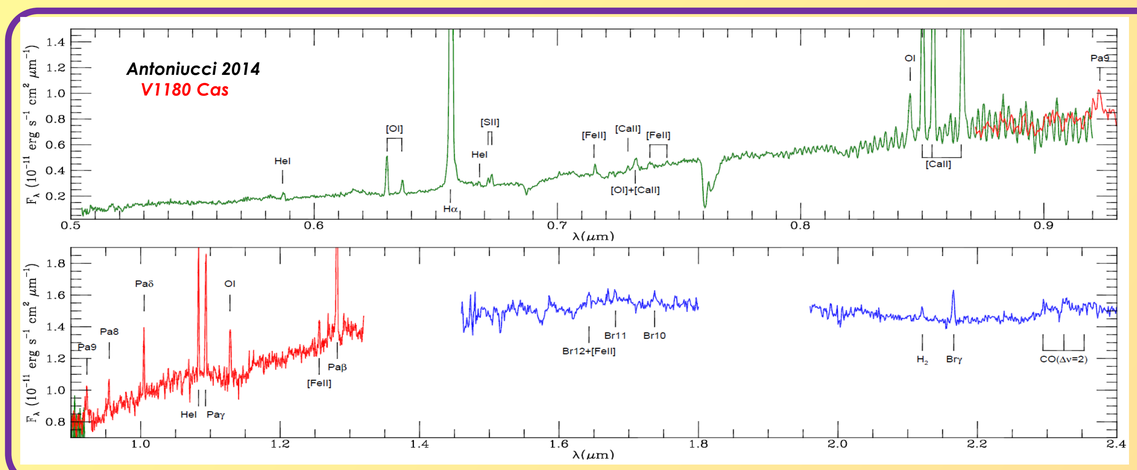


Flux and EW of Paβ in PV Cep: variations seems to be anti-correlated (black points).

⇒ **anti-correlation: increase of J continuum is larger (i.e. faster) than increase of line flux. Since EW is basically unaffected by extinction, varying extinction effects are ruled out.**

5. Light curves of the old (red), new (green) and candidates (blue) for EXors





The simultaneous detection of all these lines testifies mass-loss phenomena from the source, which is likely correlated with the ongoing accretion event. A mass accretion rate in the range1-610-8M□yr-1 was computed by using the empirical relationships that connect the line and accretion luminosity (Alcalà+2014). This value represents a unprecedented term of comparison with those that will be more easily determined later (during long-lasting quiescence periods).

Green – band J Red - band H Black – band K

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