X-shooter Science Verification Proposal

Phase-resolved spectrophotometry of the compact binary EF Eri

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Abstract:

EF Eri is a cataclysmic binary with an orbital period of 81min containing a magnetic white dwarf and a so far undetected degenerate secondary (spectral type ∼L0). Since its discovery in the 70ies it was one of the brightest CVs in the sky but entered an extended and deep low state in 1997. Data obtained occasionally in the UV-IR spectral range uncovered a complex spectral energy distribution with contributions from an accretion-heated hot spot, a magnetized white-dwarf atmosphere, quasi-chromospheric unresolved emission lines and IR cyclotron lines. X-Shooter is THE instrument to resolve and disentangle uniquely the various spectral components by Zeeman-, cyclotron and Doppler-tomography and spot mapping techniques. The proposed observations will constrain the contribution of the degenerate secondary to SED and address the question of the evolutinary status of the system.

Scientific Case:

Polars are magnetic cataclysmic binaries consisting of a late-type main-sequence star and a strongly magnetic white dwarf locked in synchronous rotation. EF Eri was one of the 11 polars known in the pre-ROSAT era, it was the second brightest at optical and at X-ray wavelengths after the prototypical system AM Herculis and the brightest in the southern sky.

EF Eri turned into a deep low state at $V \simeq 18$ in 1997 (Wheatley & Ramsay 1998) and remains therein since then with the exception of three short burps in the years 2006 to 2008. The UV-to-IR spectral energy distribution of the compact binary is disputed (Fig. 1, adapted from Schwope et al 2007). It contains photospheric radiation of a magnetized atmosphere of the white dwarf with field strength between 10 and 100 MG (Beuermann et al 2000, Euchner et al 2007). It contains radiation from an accretion-heated spot, dominant in the UV (Szkody et al 2006, Schwope et al 2007). It contains an IR spectral hump, which might be the irradiated photosphere of an otherwise undetected degenerate secondary or more likely cyclotron radiation from an accretion plasma present even in the low state (Harrison et al 2004, Campbell et al 2008). Furthermore, weak Hα emission lines originate either from the irradiated secondary or from an accretion stream (Howell et al 2006). The reason for optical variability in the low state is not known.

We propose X-Shooter observations of EF Eri in its present low state to overcome the main observational and interpretative limitation of the past: the occasional observation in this or that spectral band at different levels of activity, resulting in a non-coherent analysis.

We request observations with full phase coverage of the 81 min orbital cycle and with a phase resolution of 0.05 units. The broad wavelength range covered by X-Shooter will sample all the relevant radiation components und will uncover: (1) the temperature and field structure of the white dwarf, (2) the temperature of the accretion-heated spot, (3) the cyclotron spectrum of the accretion plasma by the detection of individual cyclotron humps in the IR or possibly the other spectral ranges, (4) the nature of the remaining weak emission lines, and (5) the possible contribution of the substellar secondary in the IR. The extension into the UV will greatly enhance our understanding of white-dwarf model atmospheres at the Balmer limit, particularly in the presence of strong magnetic fields.

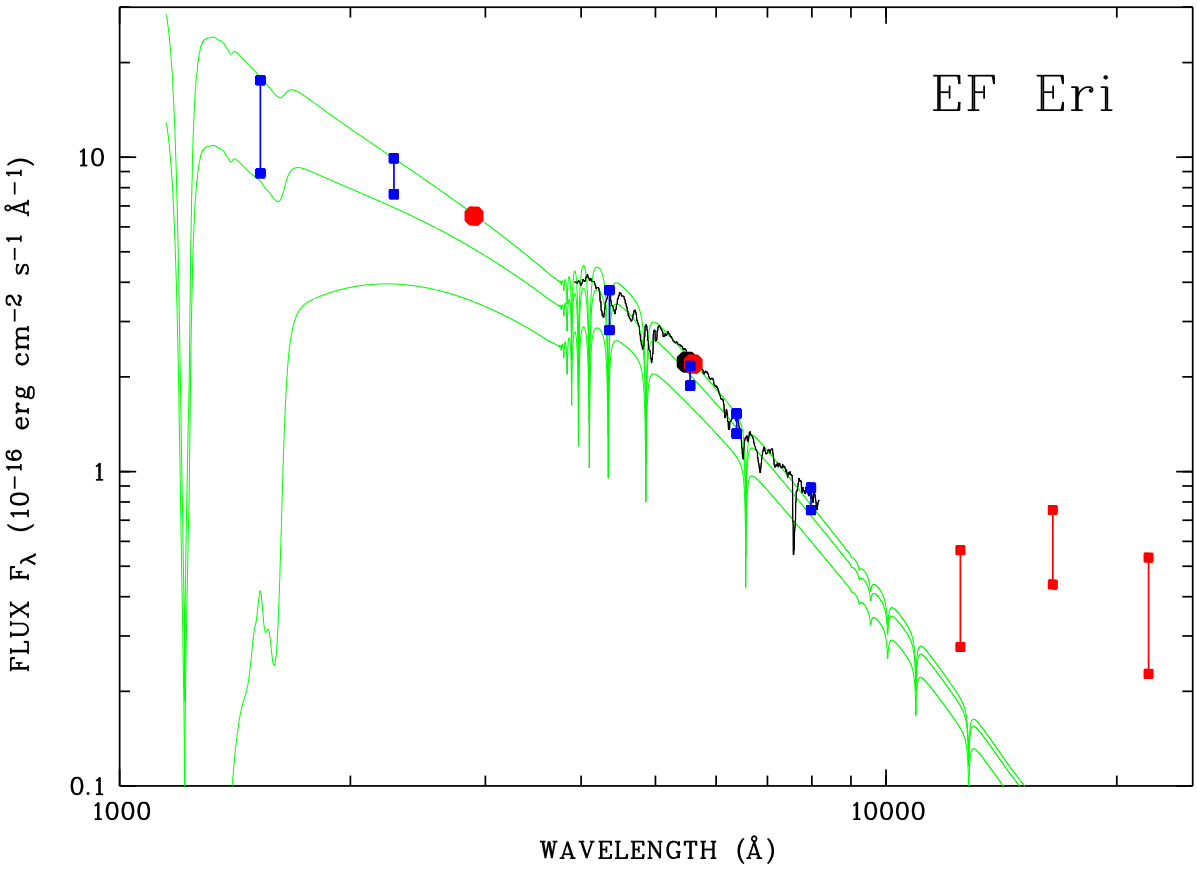

Figure 1: Ultraviolet to infrared spectral energy distribution of EF Eri in the low state. Shown are an optical low-state spectrum with strong Zeeman absorption lines and infrared JHK photometry adapted from Harrison et al. (2004), GALEX-UV and optical BVRI photometry from Szkody et al. (2006, blue dots), OM V-band and UVW1-photometry (red dots), and a spectral synthesis with a two-temperature white-dwarf model (Schwope et al. 2007) Horizontal lines at a given wavelength indicate orbital variability, when available.

Targets and observing mode

Target	RA	DEC	V mag	Mode (slit/IFU)	Remarks
EF Eri	03 14 13.0	-22 35 41	18	slit	

Time Justification:

Our request for observing time is not driven by a certain signal to noise but to achieve full phase coverage of the 81 min binary. Observations will be performed by a sequence of 20 exposures with rather short integration time of just 240sec. This mode of observation reveals a phase-resolution of 0.05, sufficient for tomographic analysis of emission and absorption lines. Following calculations with the ETC (grey time, airmass 1.2, seeing 0.8, 2x2 binning, fast readout), the observations will give S/N $10-20$ in the UV/visual arms of X-Shooter for the 240 sec subexposures, likely lower but not well specified in the IR due to the unknown spectral energy distribution. Despite its somewhat unfavourite RA, the target is visible for the requested 90min even at the beginning of August.