The Downside of EF Eridani: 6 years of SMARTS observations of a dormant Polar

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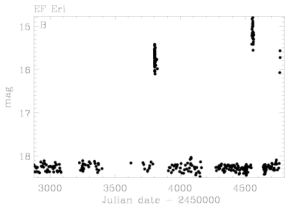
EF Eridani

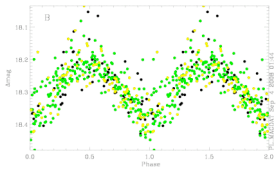
- Counterpart of 2A 0311-227
- First detected in 1974 by Ariel V
- Identified as a polar in 1978
- Bright soft X-ray source 1978 - 1997
- First reported low state: 1990
- Extended low state 1997 - present
  - brief high states in 2006, 2008 (2)

- Orbital period = 81 minutes
- Magnetic field ~ 10 MG
- Secondary: unseen, M<0.02$M_\odot$

In its prolonged low state, EF Eri offers the opportunity to study the secondary, and probe the interaction between the secondary's winds and the "magnetic maw" of the white dwarf.



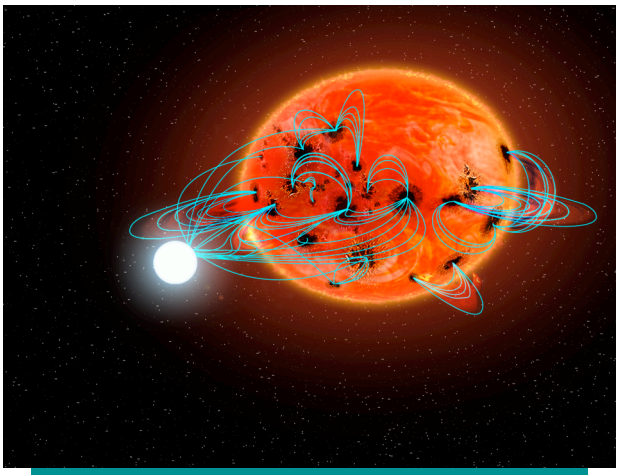
The B light curve of EF Eri from 21 August 2003 through the present. Note the long periods of quiescence interrupted by 3 short burps. The historical high state has B<15

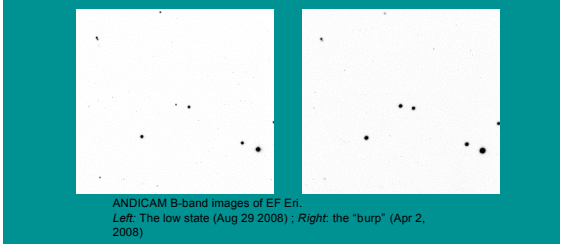


The phase-folded quiescent light curve. Colors refer to different epochs - there is no change in baseline. The upward fluctuations of up to 0.1 mag likely represent small accretion episodes.
The phasing is spectroscopic (Howell et al 2006); polarimetric zero (Bailey) is at ϕ=0.42.
Our photometric ephemeris is:
T_0=2,453,716.6103(1) HJD + 0.05626586(80)E
(period fixed; T_0 = minimum light)

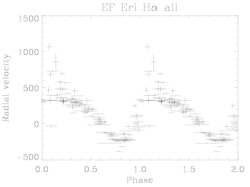
The Secondary

The secondary has never been detected.
By analogy to AM Her and ST LMi, where the secondaries are seen, the K amplitude of the secondary is about double that of Hα.
Consequently, the mass of the secondary
In EF Eri is less than found by Howell et al. (2006),
And possibly smaller than 0.02 $M_\odot$. The donor may be of planetary mass!

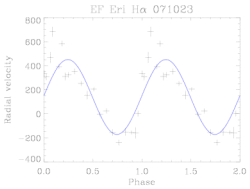




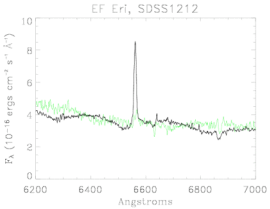
ANDICAM B-band images of EF Eri.
Left: The low state (Aug 29 2008) ; *Right*: the "burp" (Apr 2, 2008)



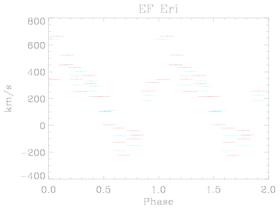
The Hα radial velocities at 10 epochs, from the SMARTS 1.5m RC spectrograph.



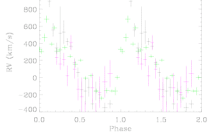
A sinusoidal fit to the Hα radial velocity. The trend is clearly not sinusoidal.



The Hα region from the CTIO 4m, with LARP SDSS J1212+0136 overplotted for comparison.



The radial velocity curves from Hα (red) and H β (blue), from the CTIO 4m in February 2008



Black: High state Hα 080328
Green: Low State Hα 071023
Magenta: High State He I 6678 080328

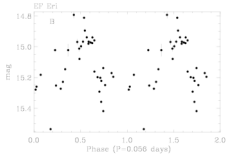
Hα

The Hα emission likely arises in a region where the wind from the secondary interacts with the magnetic field of the white dwarf. This is on the secondary's side of the center of mass. This is the same place in the low and high states: the figure to the right compares the Hα radial velocities in the two states.

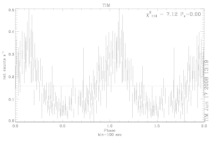
The Burps

Three have been seen:

- March 2006: Rise < 12^d Duration > 23^d Decay <77^d
  - Ended while behind the Sun
- March 2008: Rise < 4^d Duration > 86^d Decay <10^d
  - Swift, RXTE observations
- October 2008: in progress; started 24 October
  - Swift observation Oct 30
  - Rise: 2 mag in 4 days; 3 mag in 8 days
- These are not returns to the historic high state.



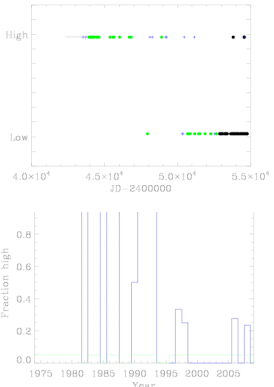
Above: Folded B-band light curve of the March 2008 burp. This was constructed from observations on many days; scatter may be due to this.
Below: The Swift light curve on 9 June 2008, just before the end of the burp.



Is EF Eri Awakening?

From its discovery in 1974 through 1990 EF Eri was never seen in a low state.
From 1990 through 1998 it was mostly high.
It was always low 1999 through the March 2006 burp.

The figure below shows this schematically;
Green points are X-ray observations;
Blue points are optical from the literature;
Black points represent our SMARTS data.



This figure shows the fraction of days EF Eri was seen in the high state (blue), by year.
The green line >0 when data exist.
Because the observing is irregular, this is not the fraction of time the source is high.

There is a suggestion that EF Eri is beginning to turn on, again.

References

Howell et al. 2006, ApJ, 652,709