

The Be Binary Dschubba and Its 2011 Periastron Passage

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Outline

- **Parameters of the δ Sco binary**
- **The primary's disk during the last orbital cycle**
- **Spectroscopy during the periastron 2011**
- **What kind of system is δ Sco?**
- **Conclusions**

Parameters of δ Sco

Optical brightness without disk, $V=2.32$ mag

Spectral type B0.3 IV

Distance, $D = 123 \pm 15$ pc

Luminosity, $\log L/L_{\odot} = 4.4 \pm 0.1$

Surface temperature, $T_{\text{eff}} = 27500 \pm 500$ K

Surface gravity, $\log g = 4.0$ (typical of a dwarf)

Binary system with an angular separation

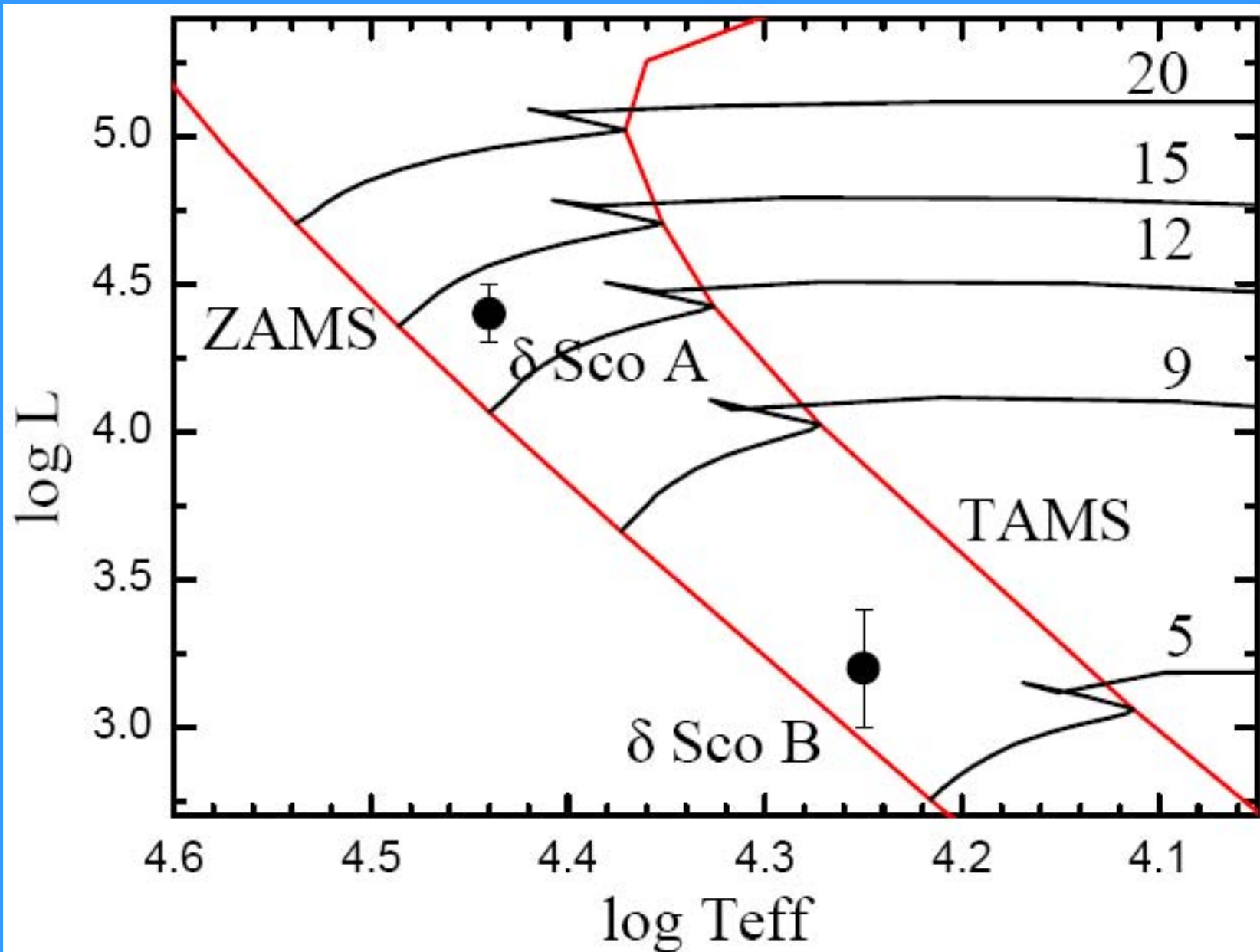
from $0.''2$ (apastron) to $0.''006$ (periastron)

Orbital period, $P = 10.8$ years

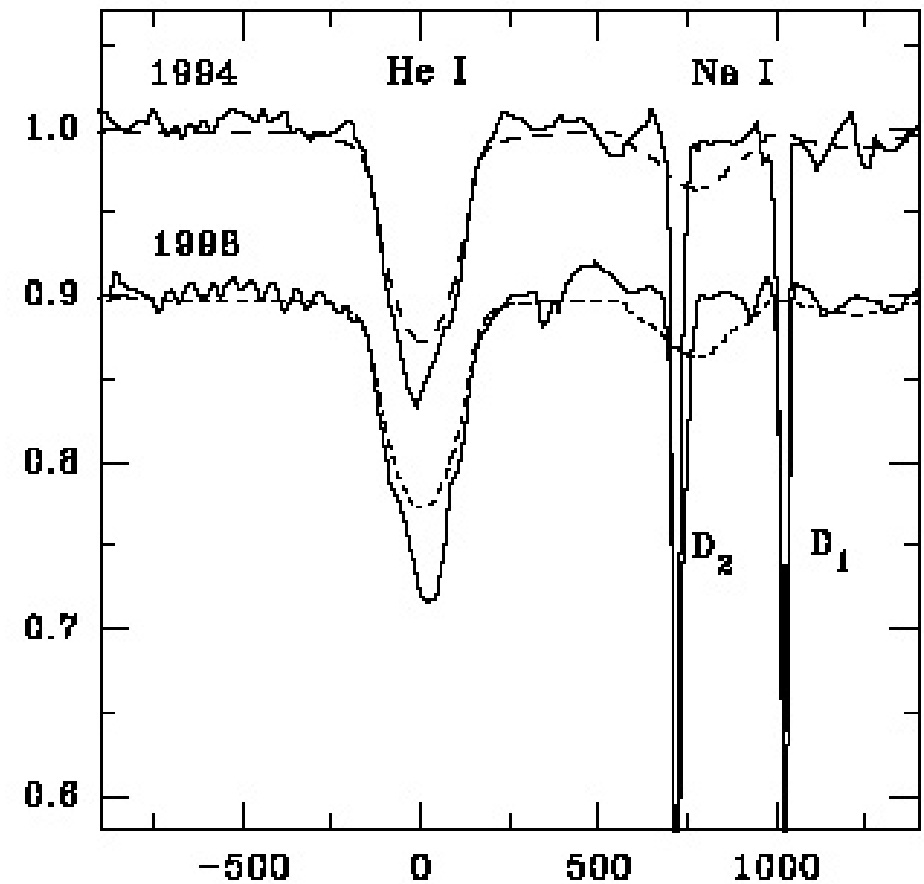
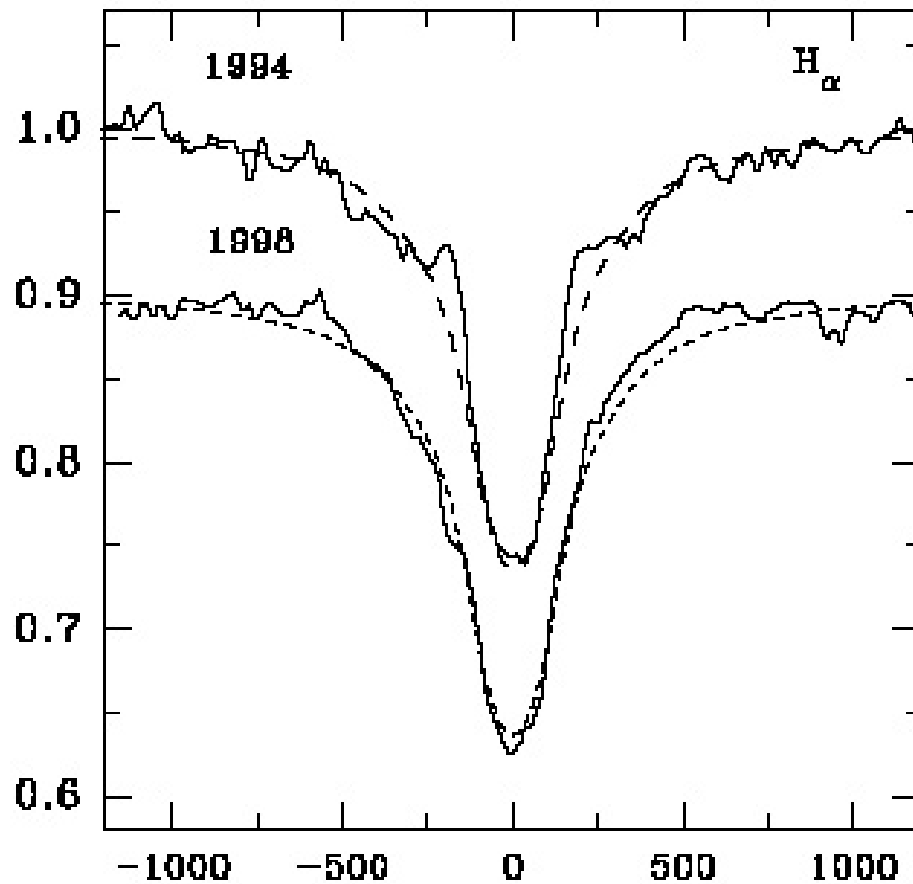
Eccentricity, $e = 0.94 \pm 0.01$

Secondary, $\Delta V \sim 1.7$ mag, Sp.T. \sim B3 (uncertain)

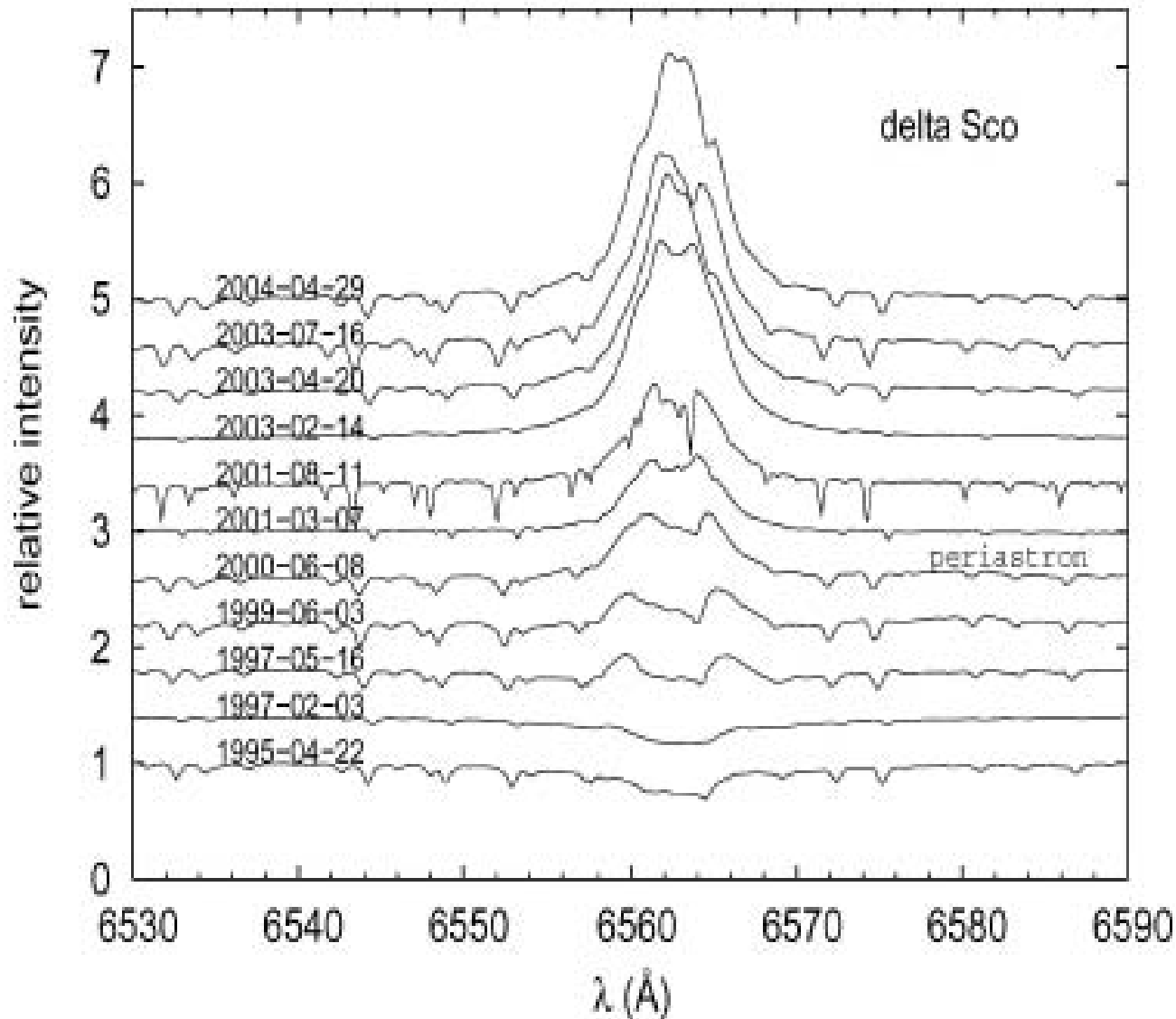
δ Sco in the HRD



δ Sco without Disk

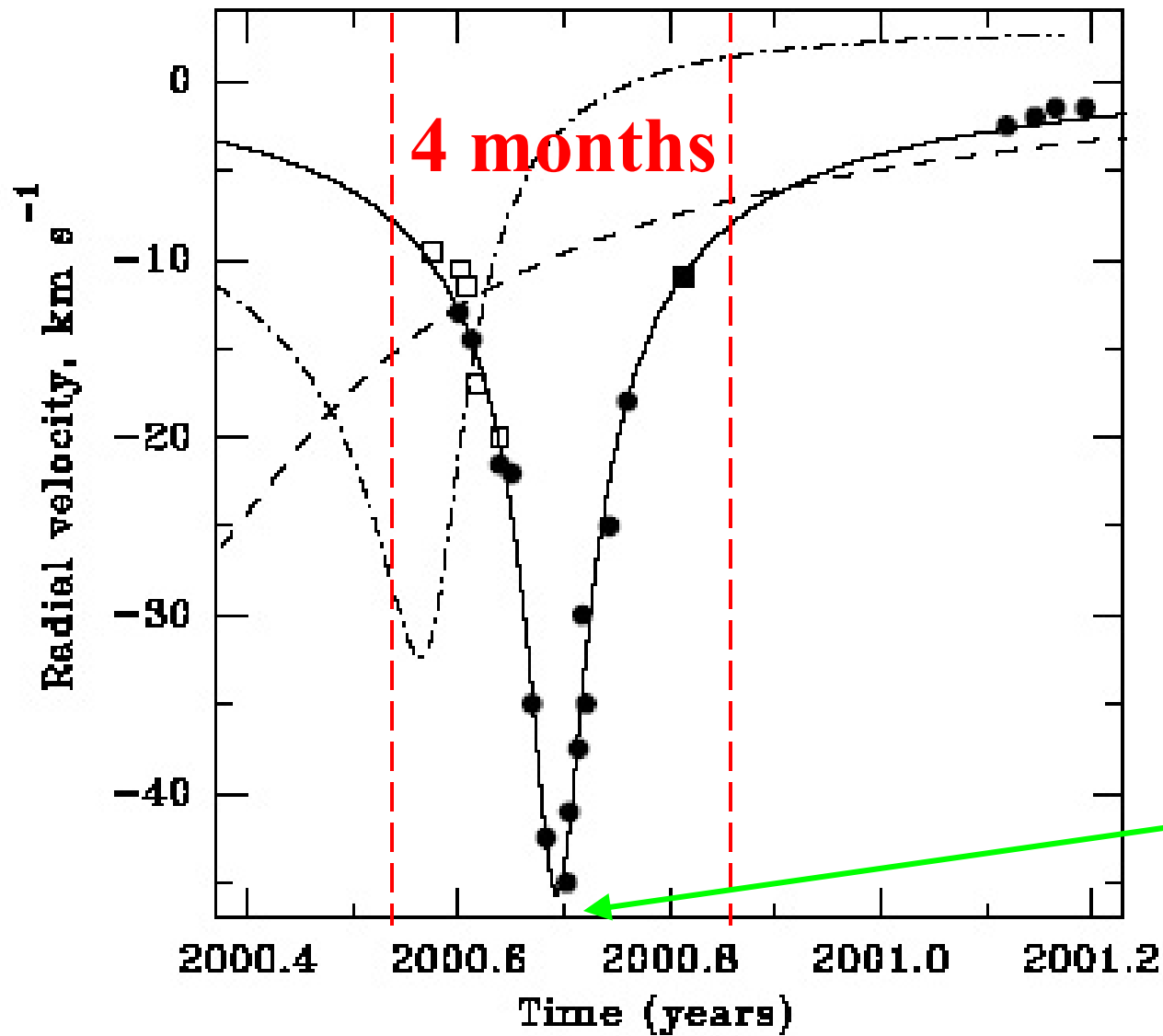


When did the Emission Appear?



Koubsky 2005,
*Astrophys. &
Space Science*,
296, 165

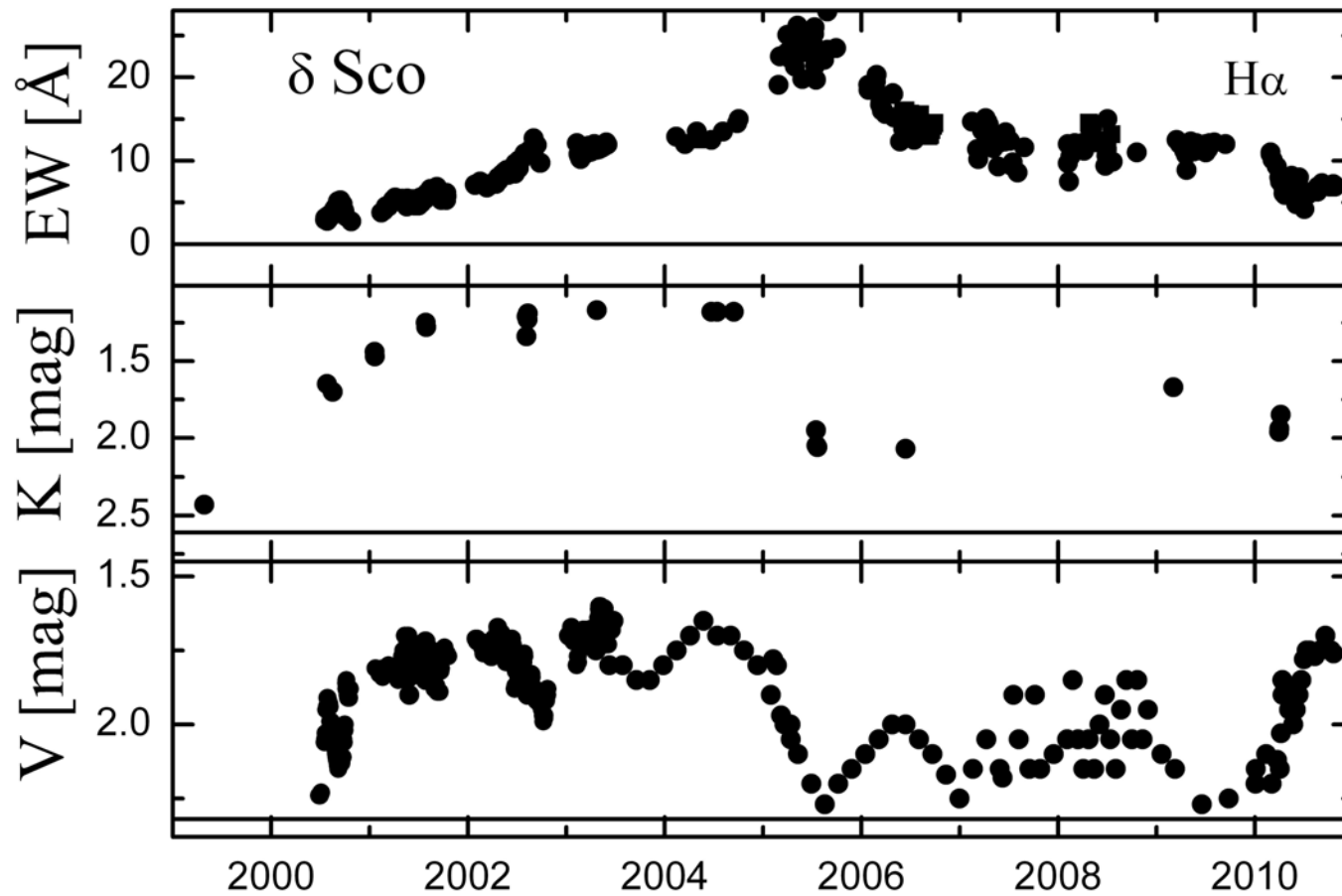
Orbit of δ Sco



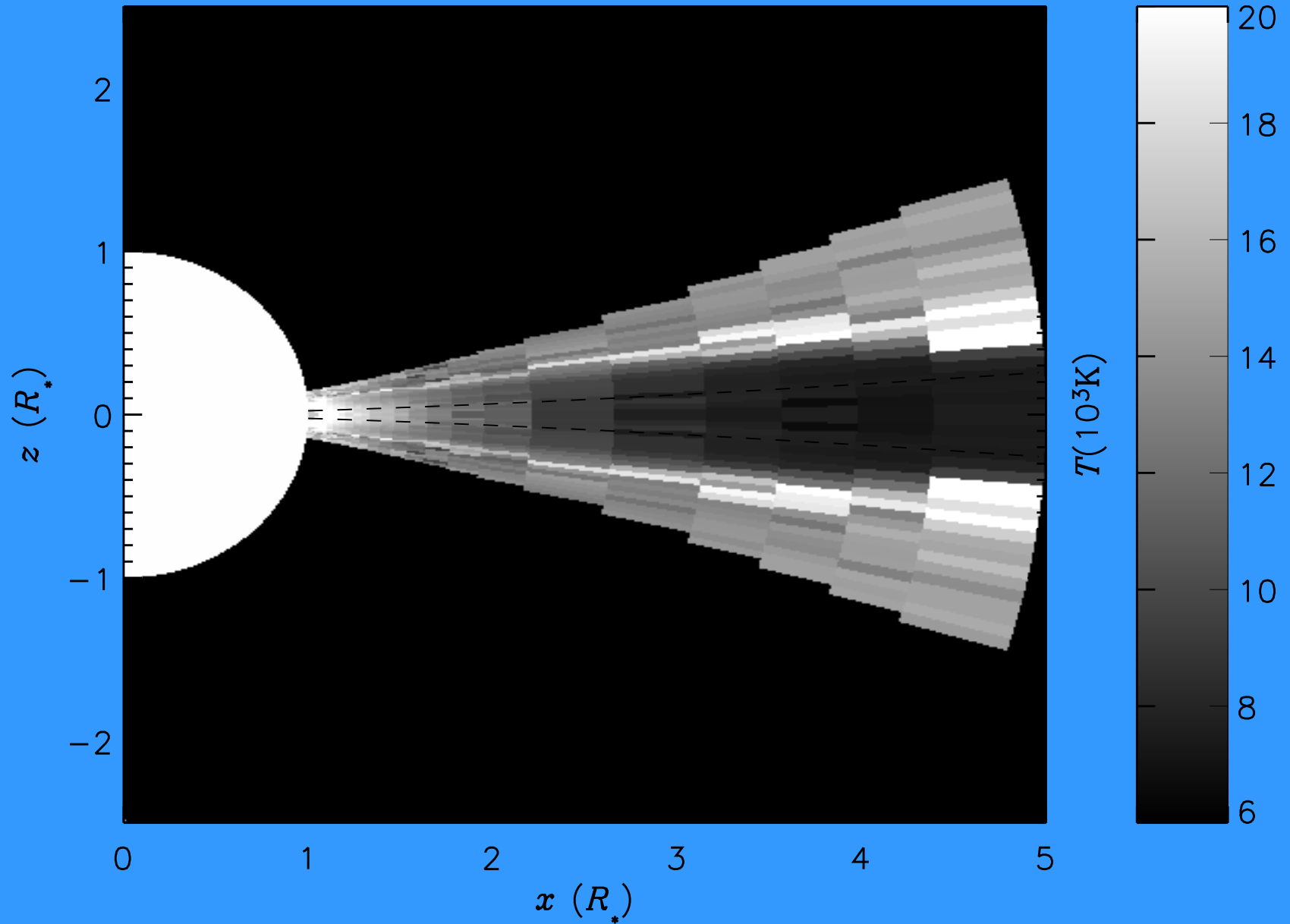
Bisector radial velocities of the H α emission line near periastron in 2000

Add 10.8 years

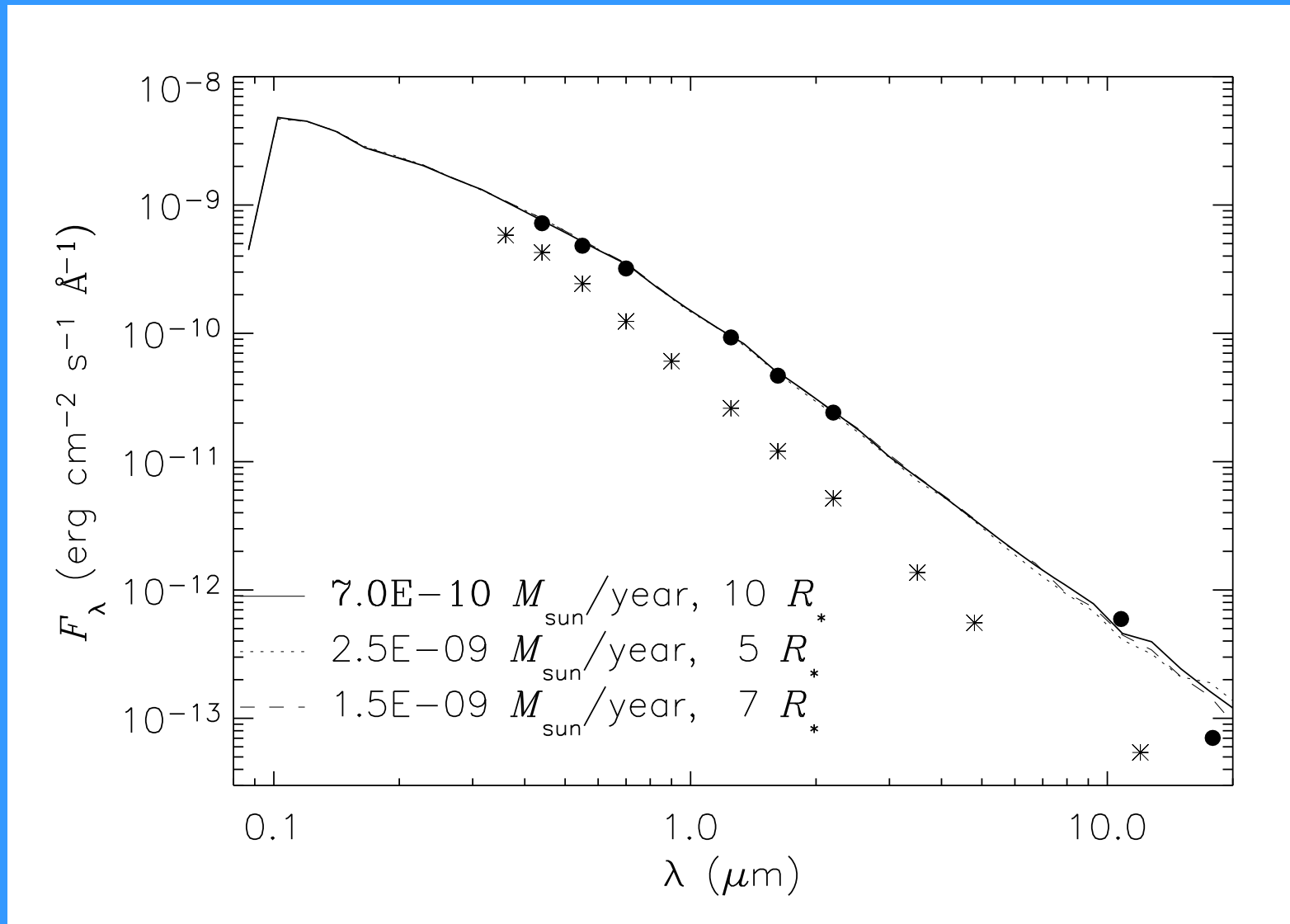
Brightness – Spectrum



Disk in 2001



Disk in 2001



From Carciofi et al. (2006, ApJ, 652, 1617)

Goals of the 2011 Campaign

Take spectra as frequently as possible to:

- obtain a well-defined radial velocity curve to independently constrain the orbital period
- study line profile variations to search for effects of the tidal interaction on the disk and possibly get some information about the secondary component

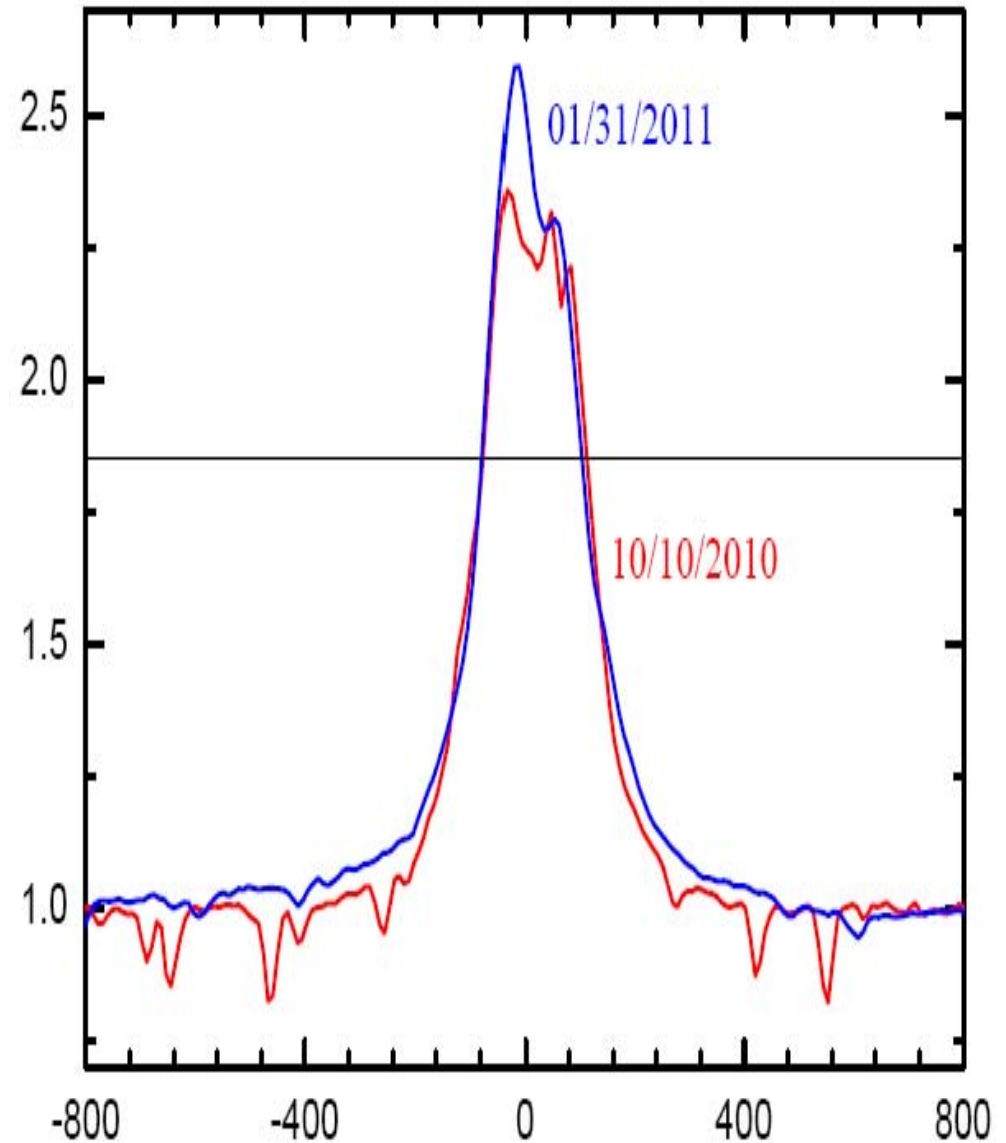
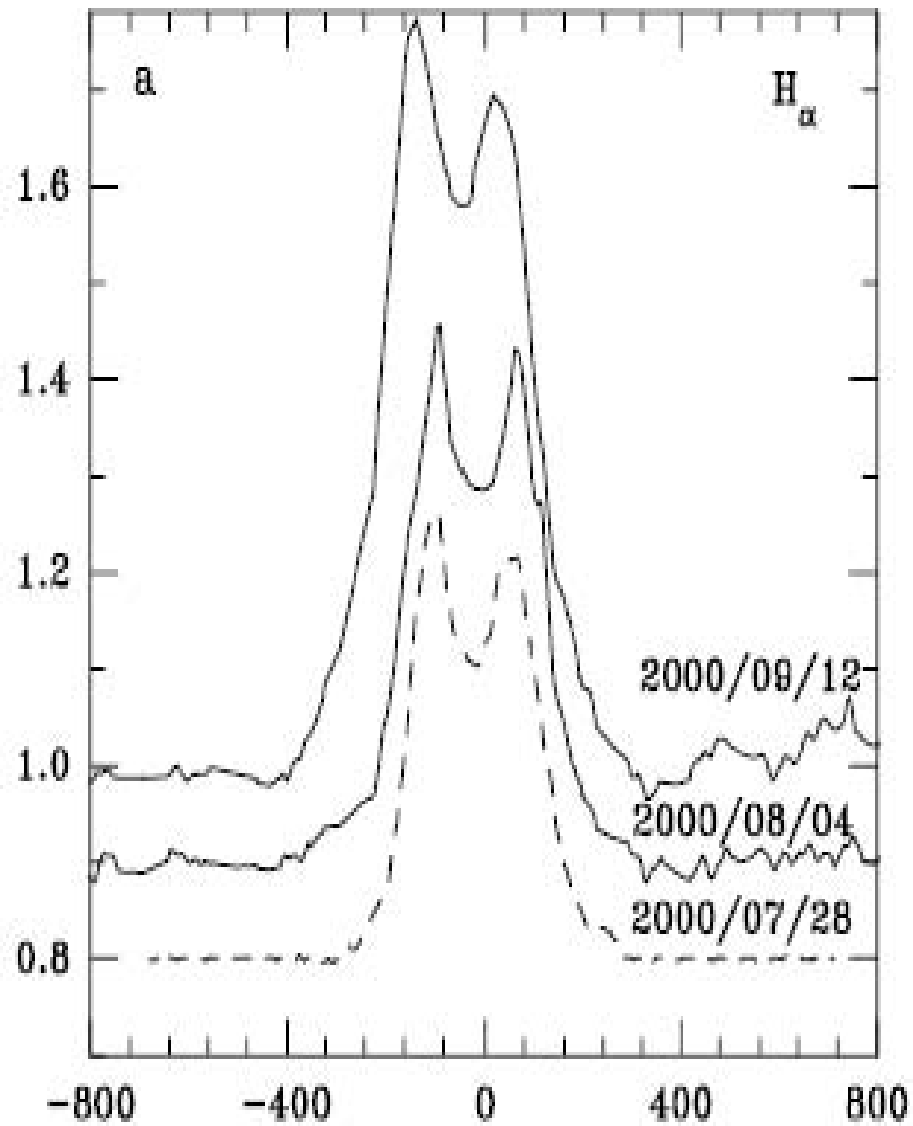
Numbers of spectra obtained:

Year	Professionals		Amateurs	
	spectra	nights	spectra	nights
2000	30	30	2	2
2010	~200	30	~200	83
2011	~300	40	~300	149

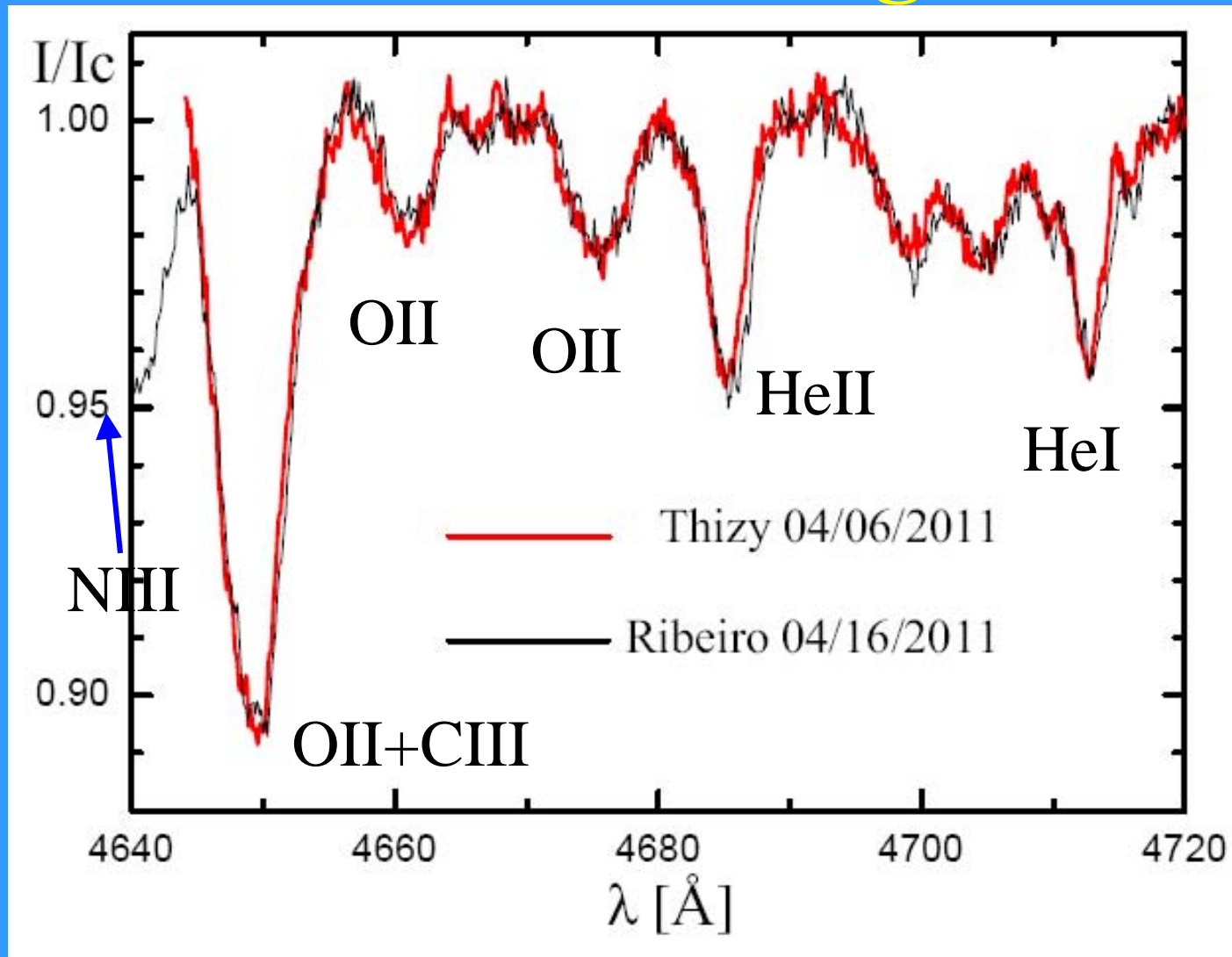
H α line in 2000 and 2010/11

Ritter Obs., Toledo, OH

Amateurs

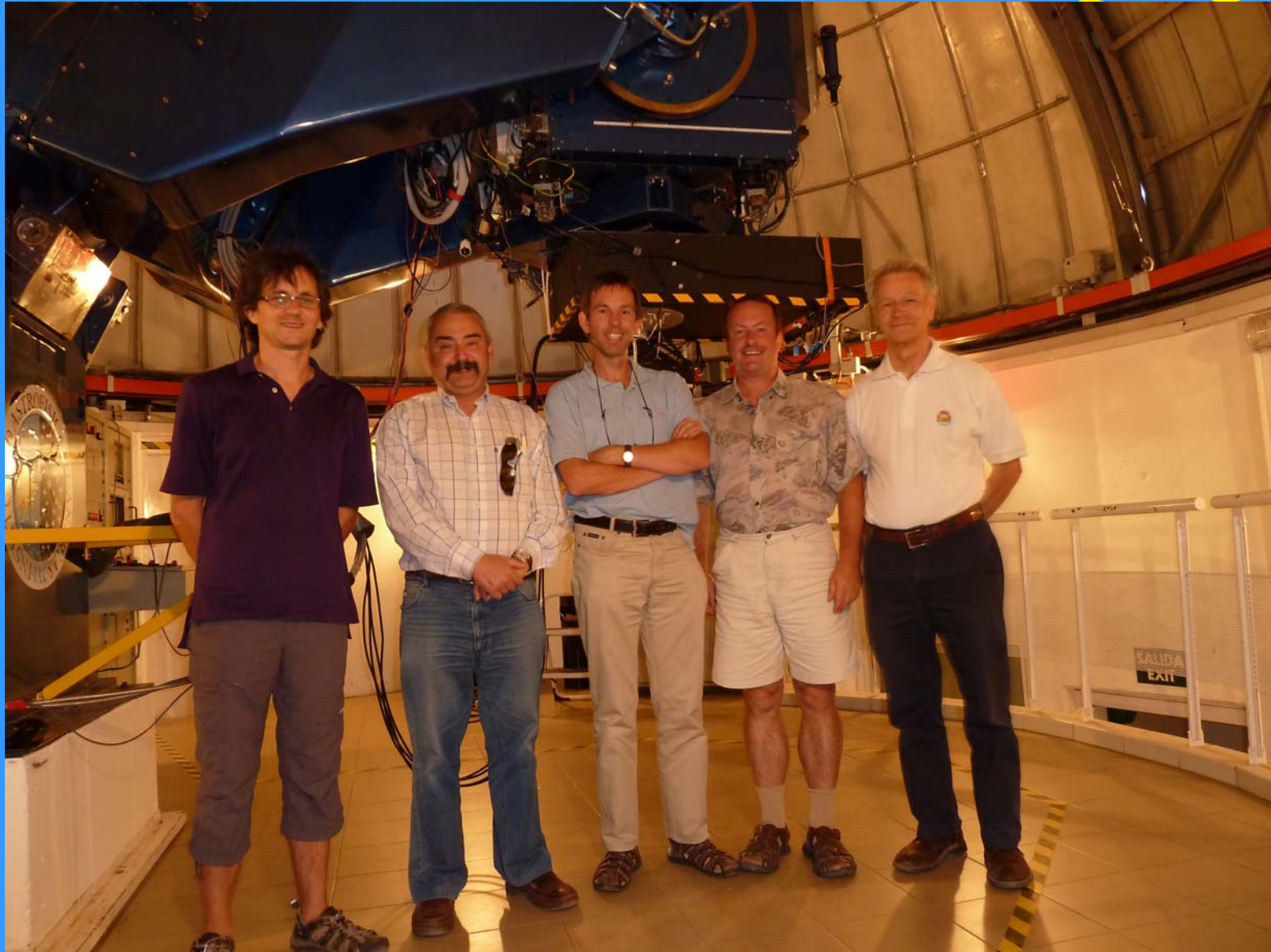


He II 4686 Å Region

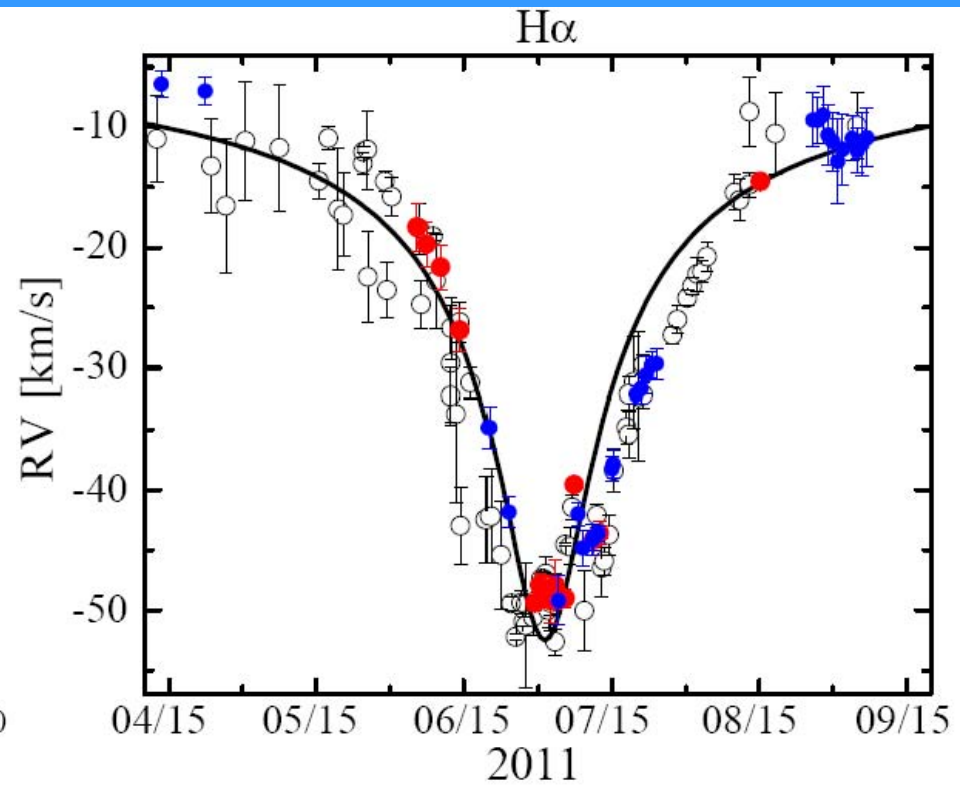
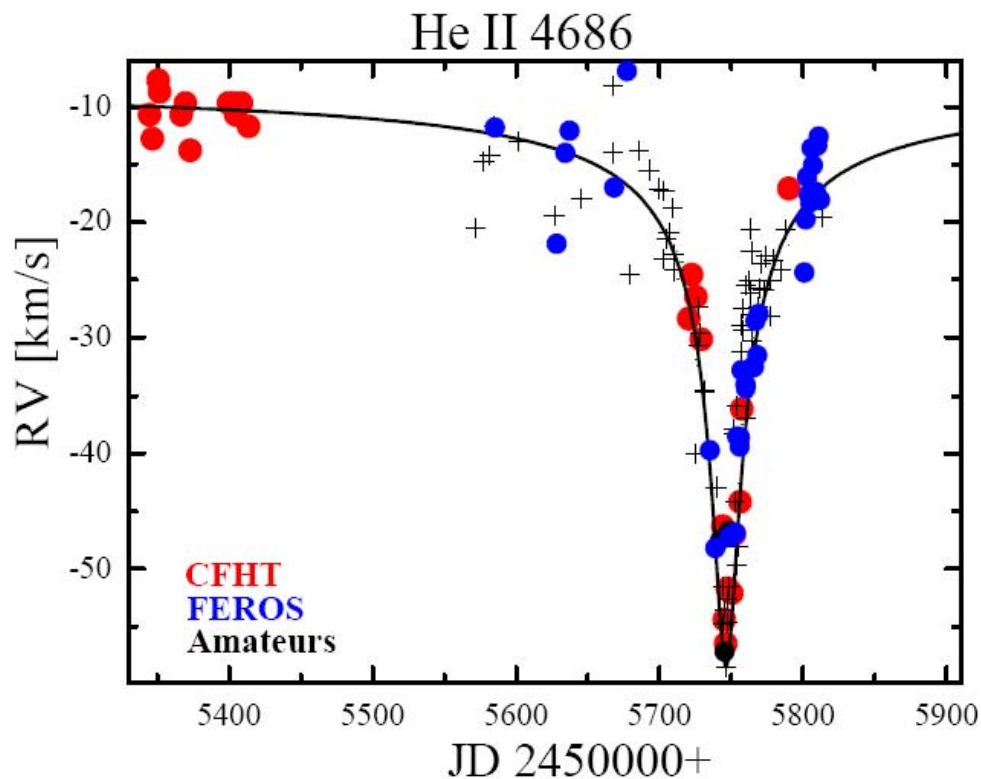


http://www.uncg.edu/~a_mirosh/Delta_Sco

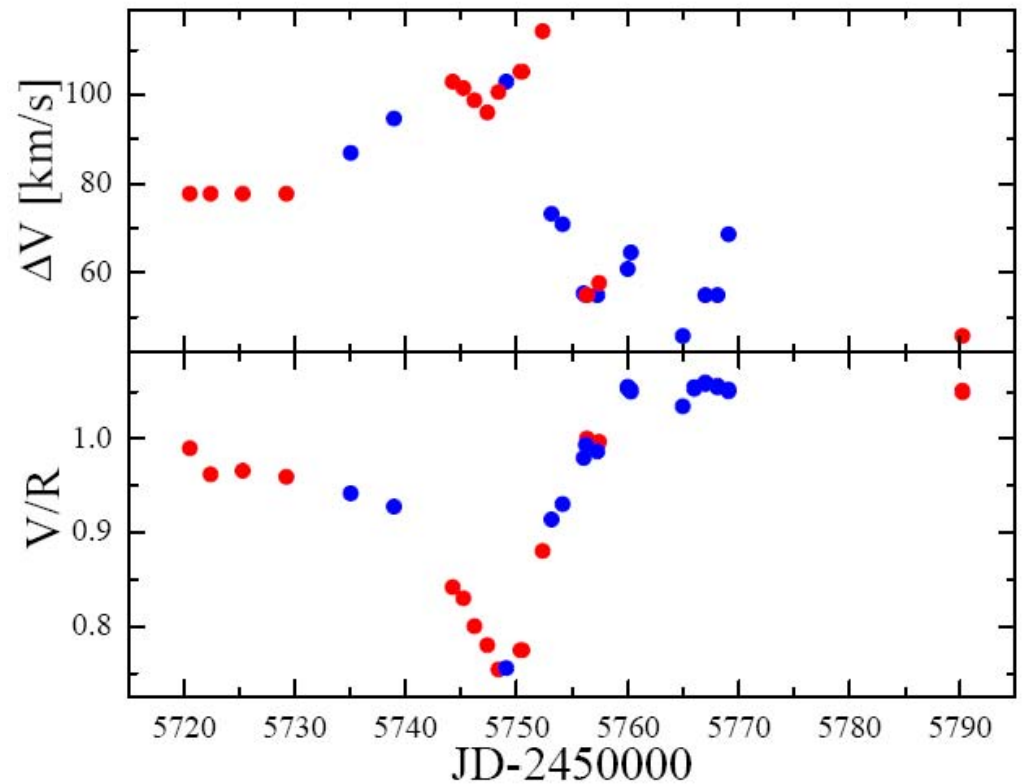
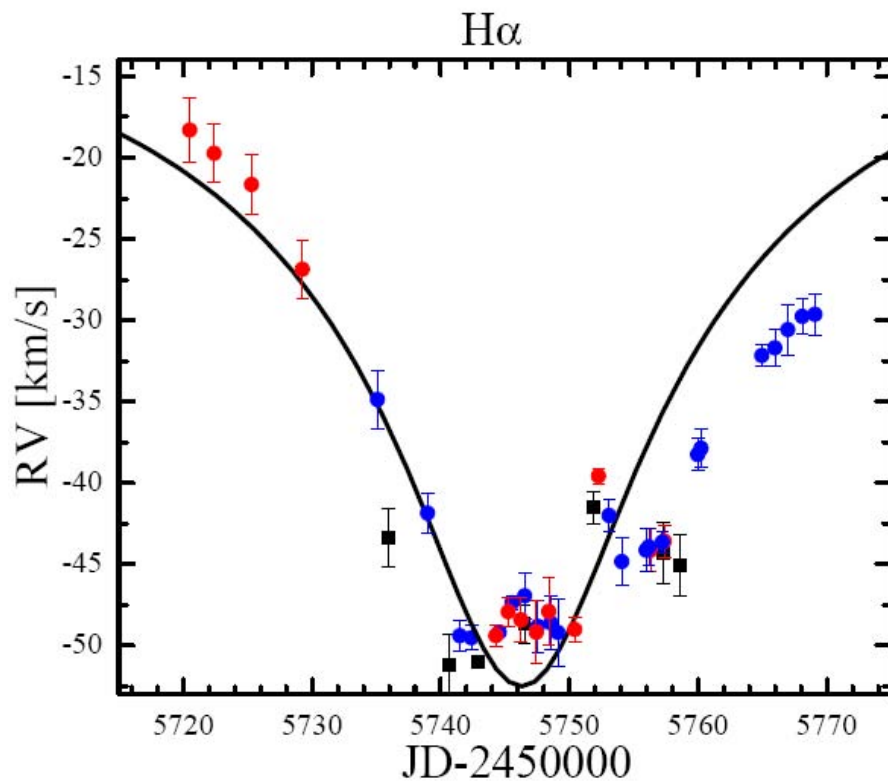
The IAC80 Periastron Campaign



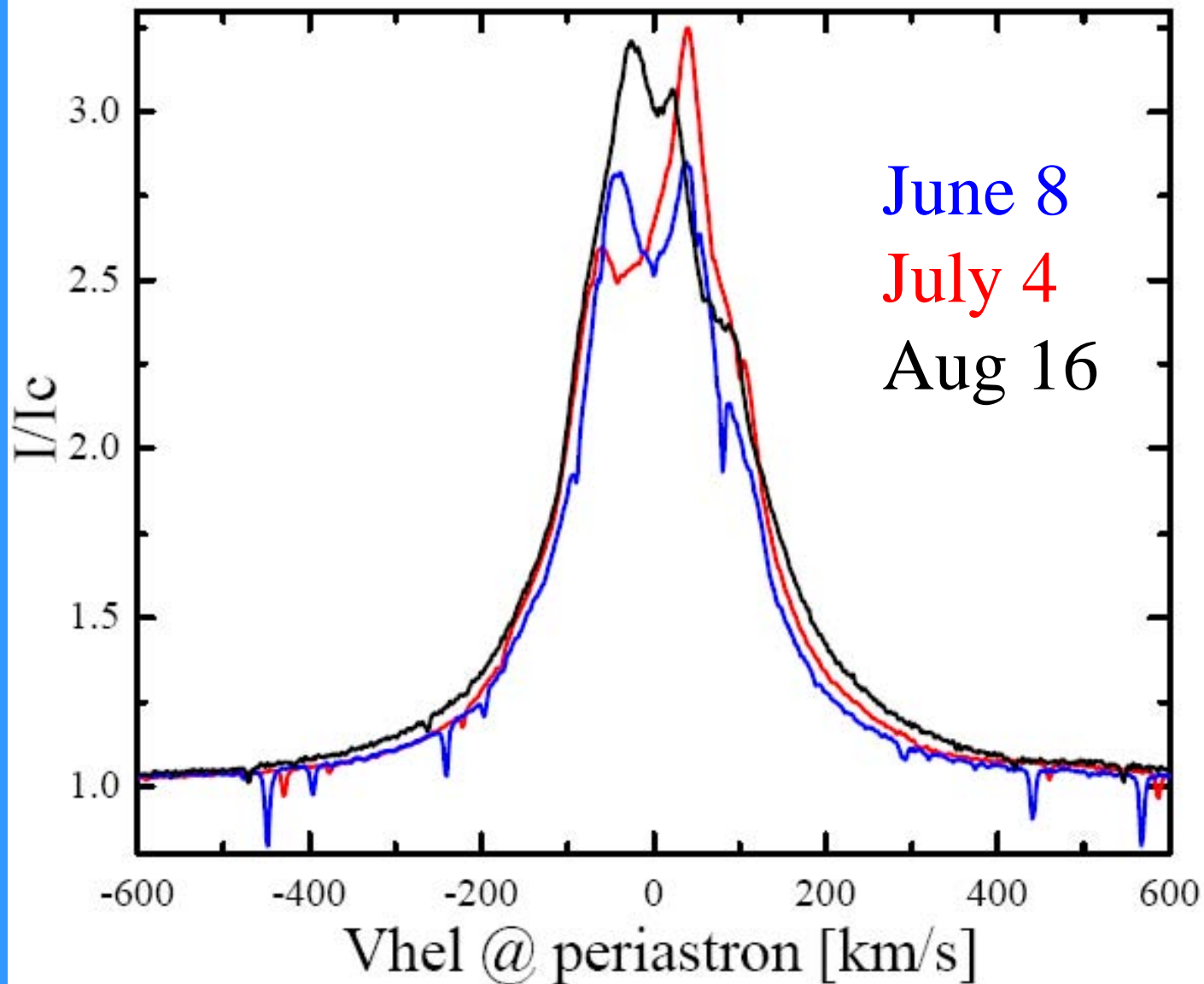
RV Curves at Periastron 2011



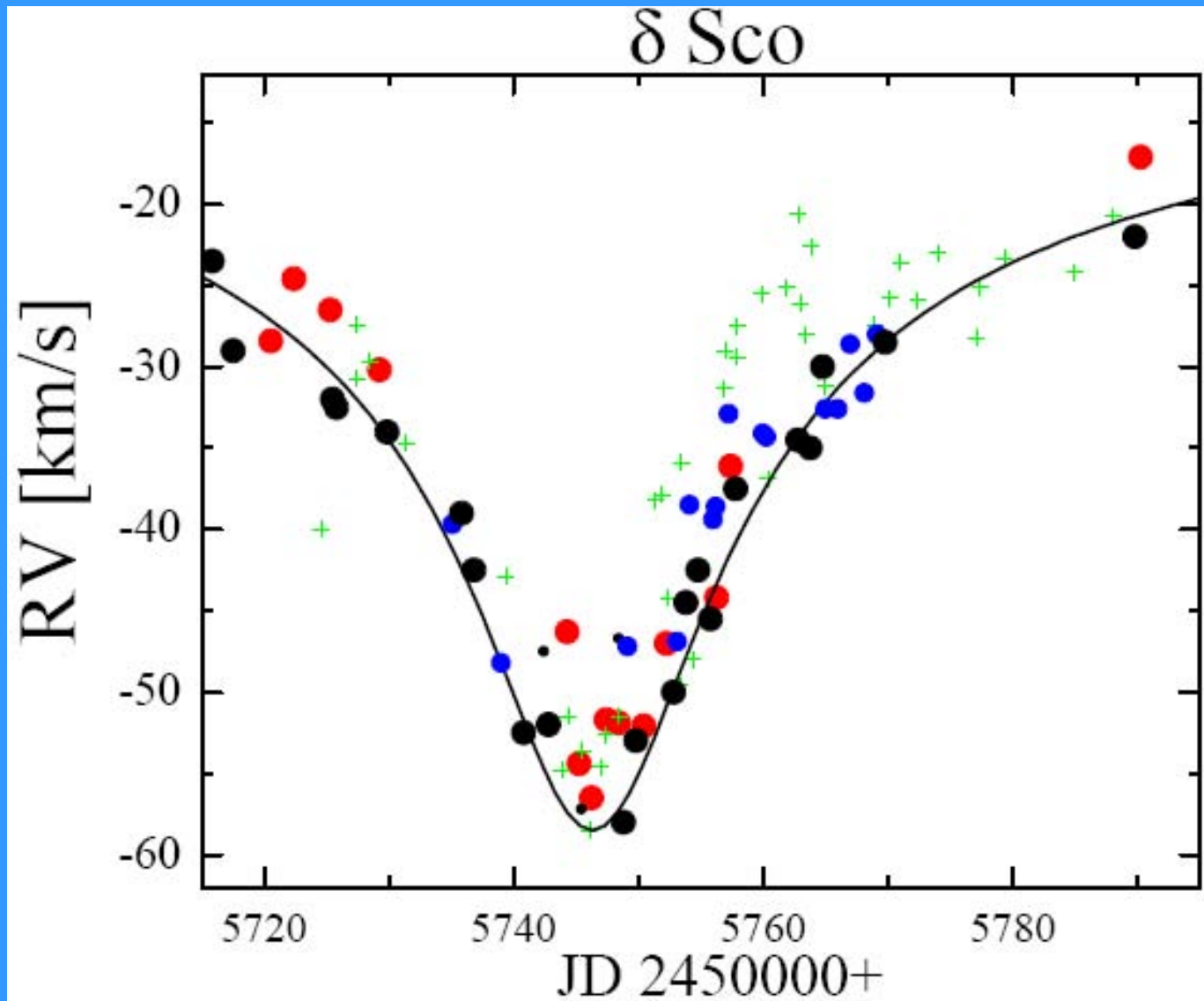
Periastron in $H\alpha$



H α Profile at Periastron

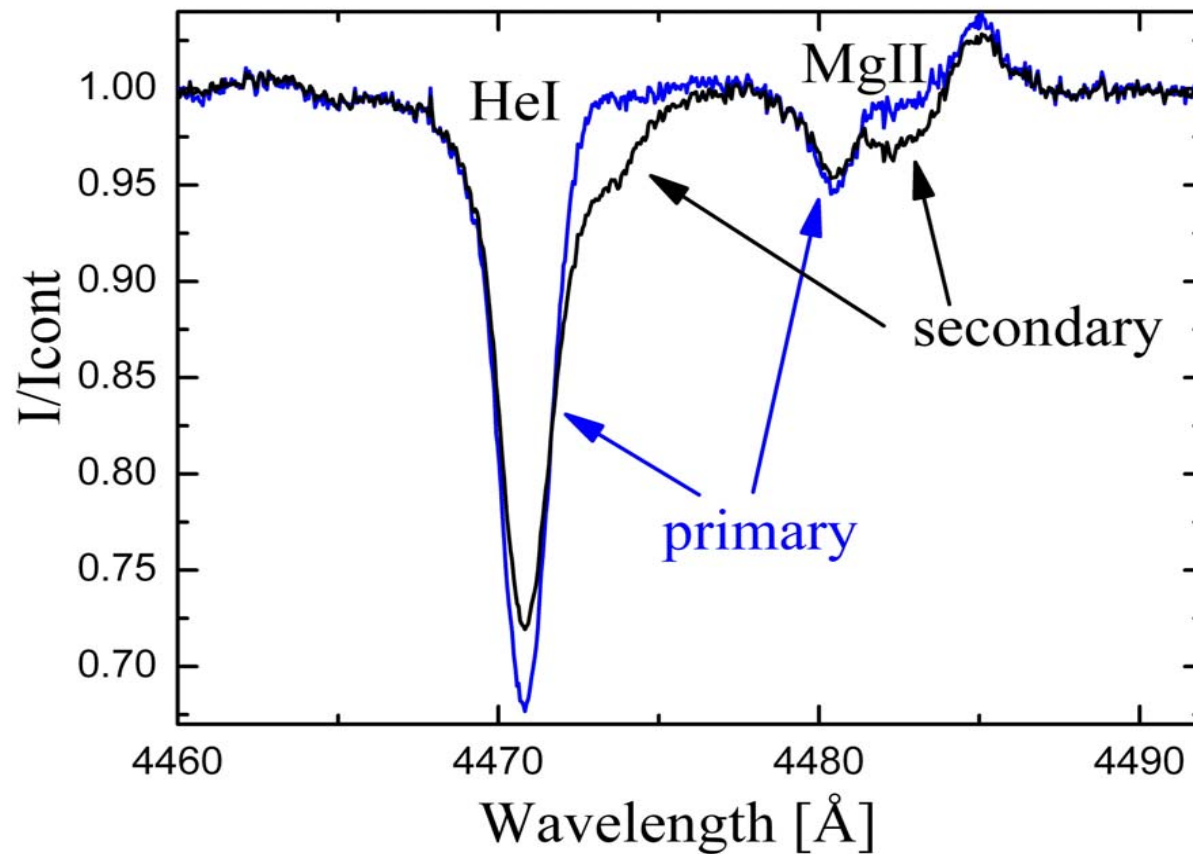


Periastron in He II 4686 Å



Secondary's Trace at Periastron

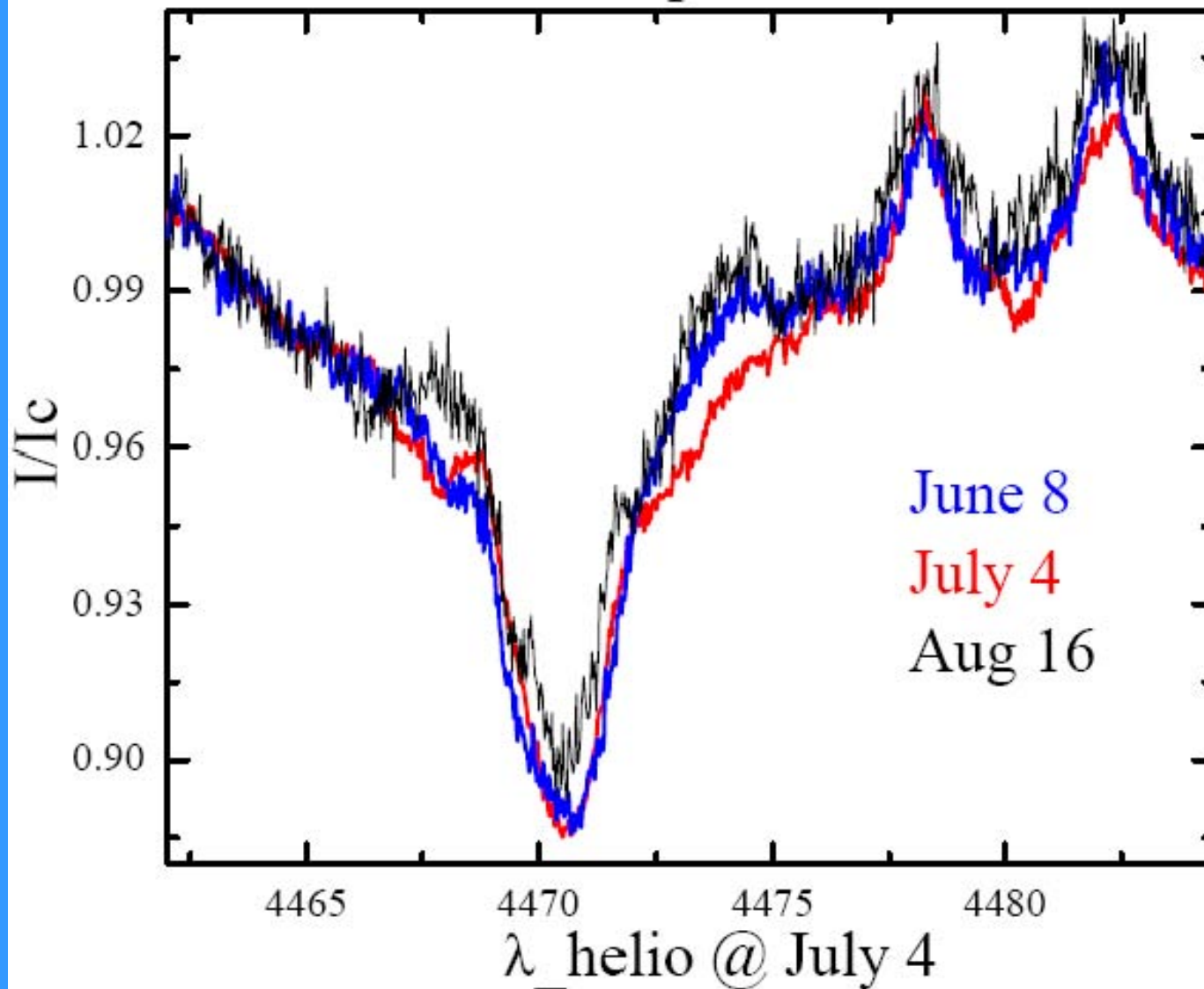
Radial velocity difference is ~ 120 km/s



B0 + B3, both $v \sin i = 150$ km/s,
brightness ratio $\Delta V = 1.7$ mag

Observed He I 4471

HeI 4471 at periastron 2011



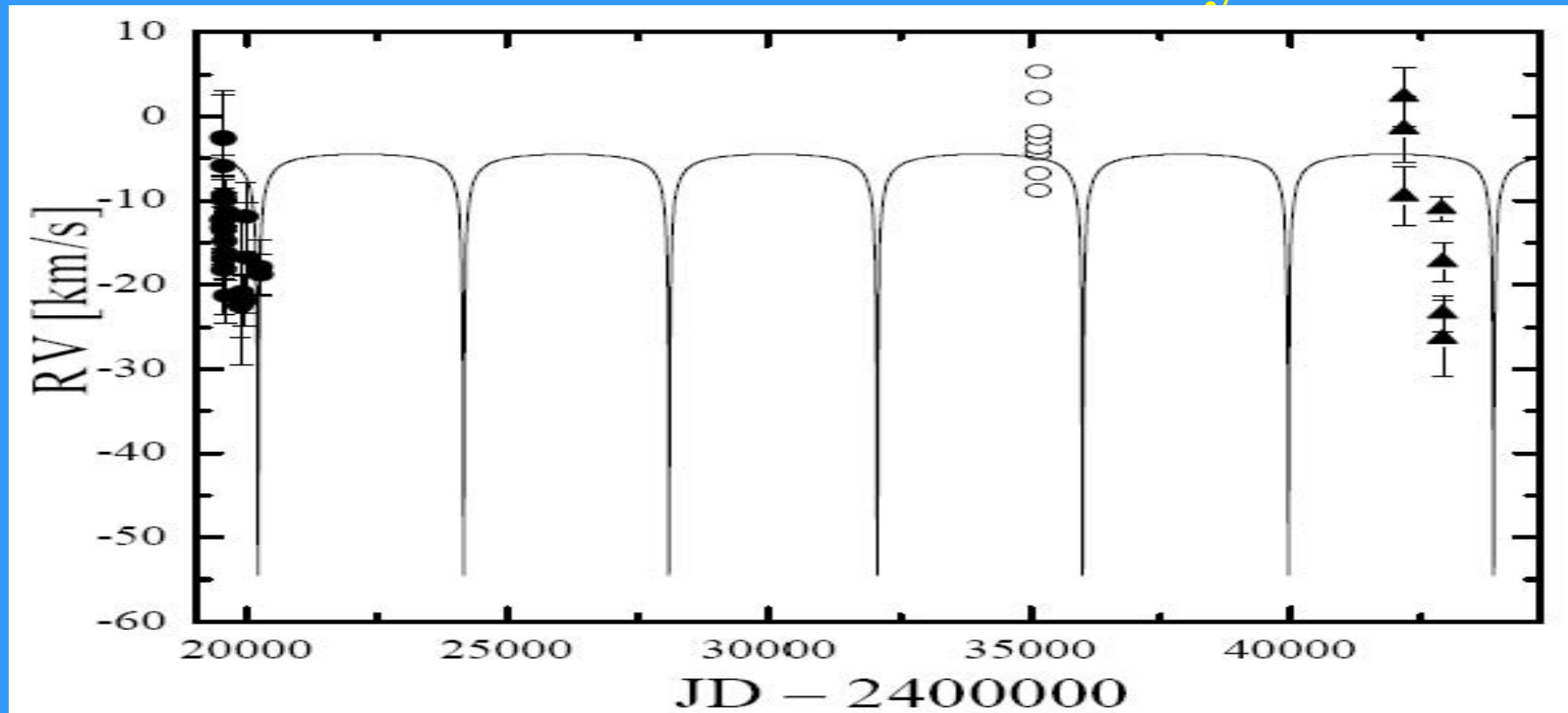
What Is δ Sco?

- The Bright Star Catalog mentions a component with a 20-day orbital period
- Most Be binaries with non-degenerate secondary components have circular orbits.
- Radial velocities in the XX century show variations additional to those expected at periastra.
- Be/X-ray binaries have eccentric orbits.
- The system is surrounded by a dusty envelope seen that could have resulted from an explosion.

Hypotheses:

- ✓ There is a third, degenerate(?) star in the system
- ✓ The binary is a runaway from a cluster

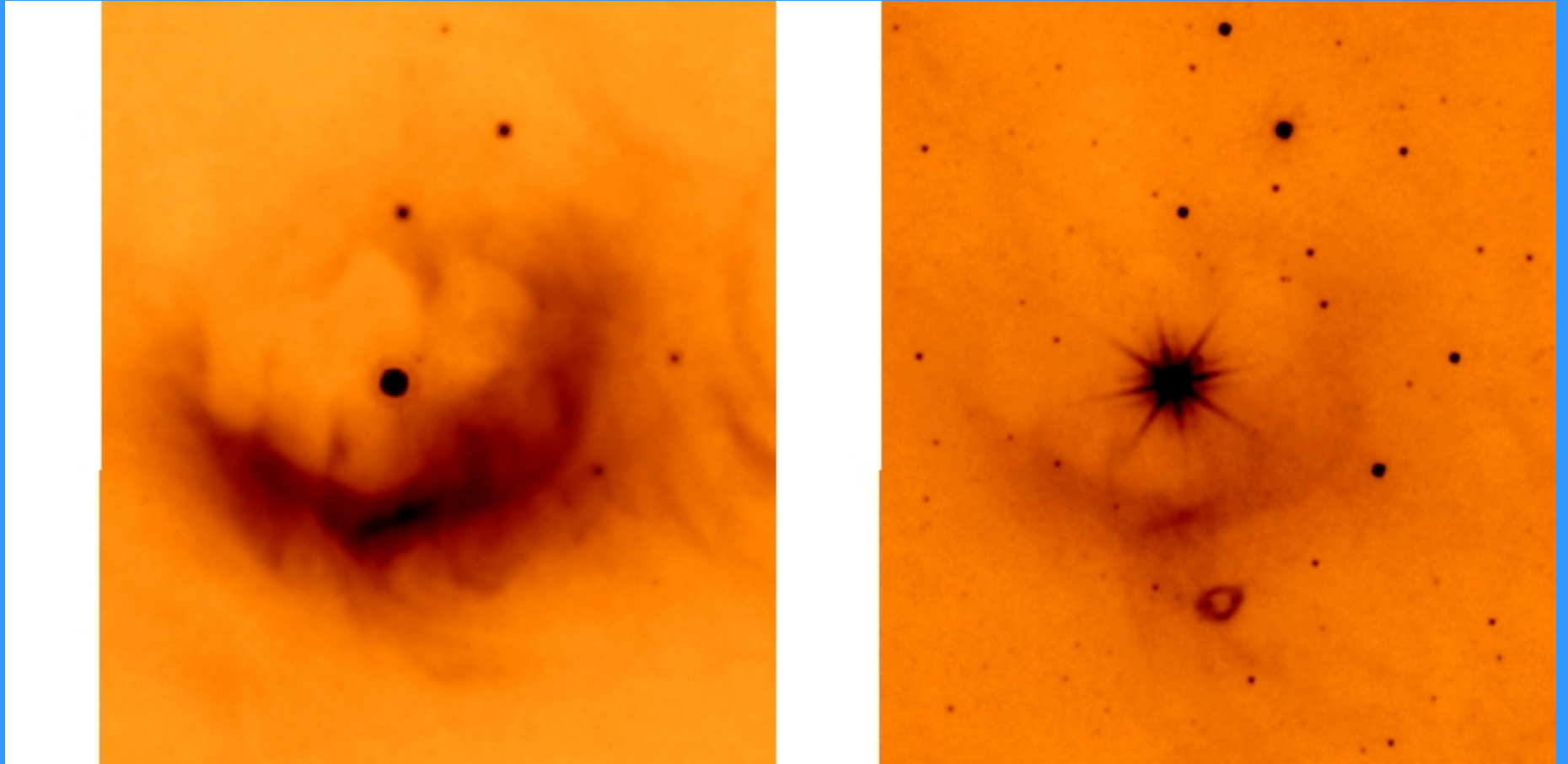
Historical Radial Velocity Data



Periodogram and stability analysis by A. Pasetchnik:

- Periods shorter than ~ 10.5 years are insignificant
- Any internal component is unstable after few orbits
- Orbital period may change due to an external component

The Shell of δ Sco



WISE images at 22 (left) and 12 (right) microns
(found by Vasilij Gvaramadze, Sternberg Inst., Moscow, Russia)

Conclusions

- Orbital period is 10.8147 ± 0.0013 yr = 3950 ± 5 d
- Spectroscopy near periastron did not clearly reveal properties of the secondary that is consistent with an early- to mid-B spectral type
- The IR shell near the system suggests that it is a runaway from a young cluster
- The radial velocity in 2011 curve slightly deviates from that in 2000 (possible 3rd component)
- The 2011 campaign reveal that amateur spectroscopy becomes an important factor in astronomy of emission-line stars