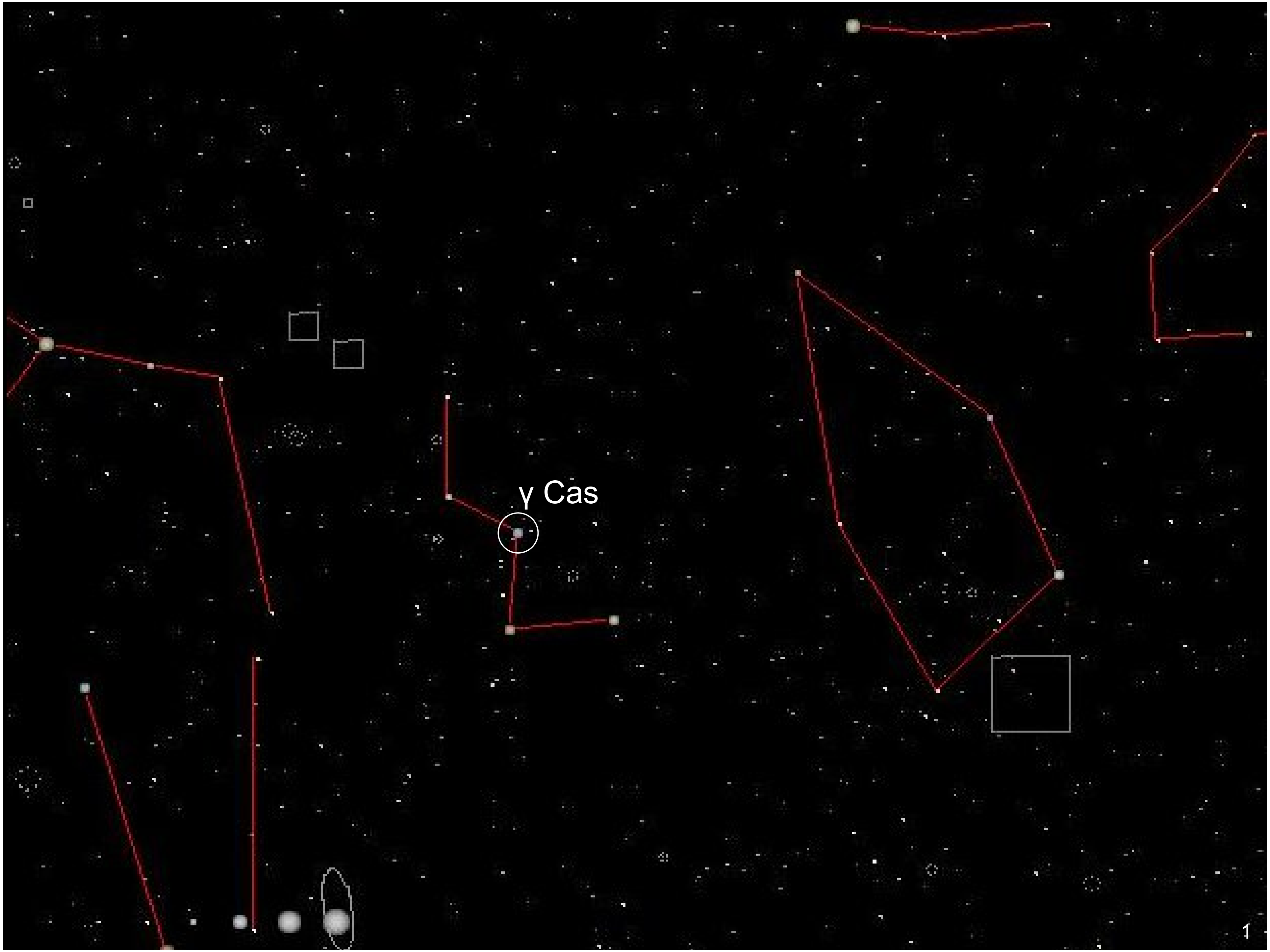
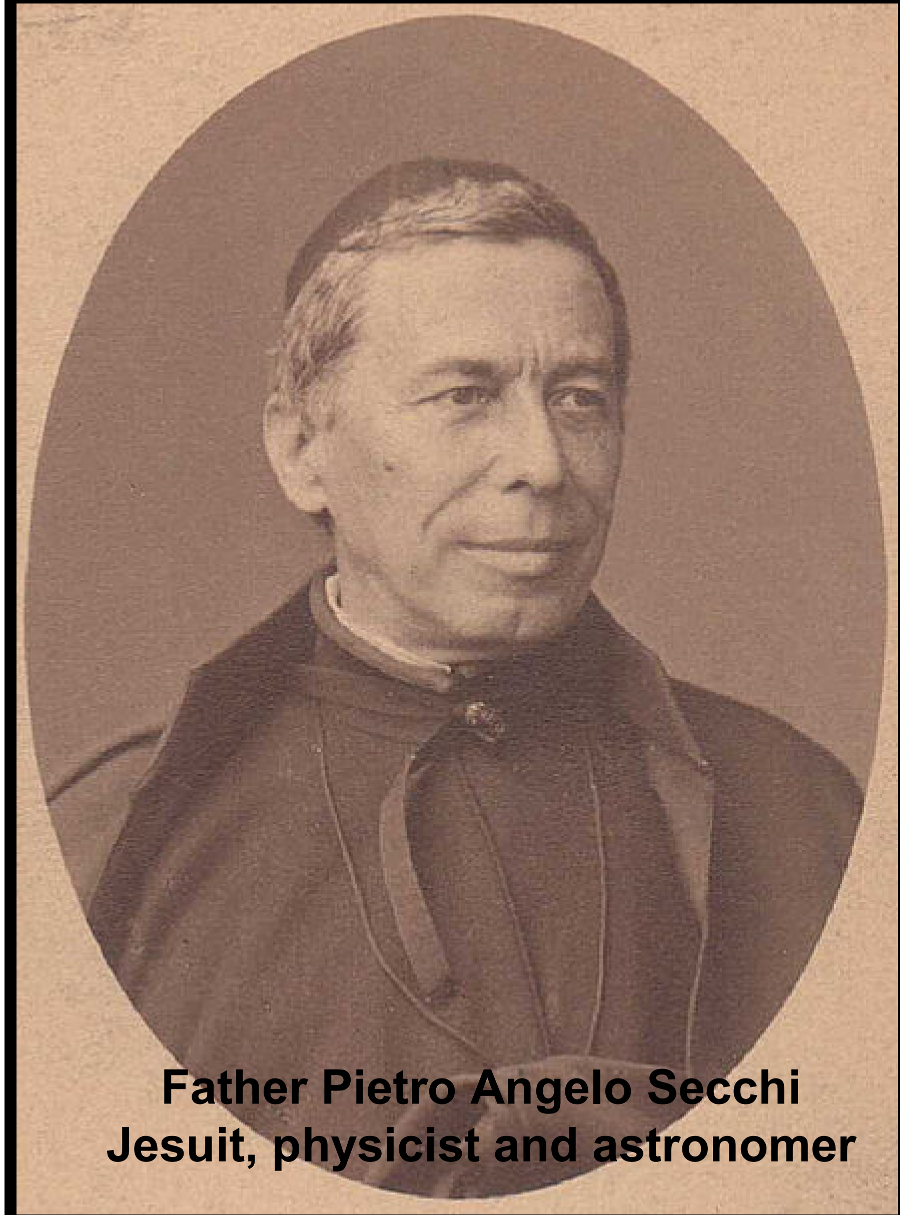
Portrait of the Be Star
γ Cassiopeia

24. November 2018
Observatory TIVOLI, Oudenbosch

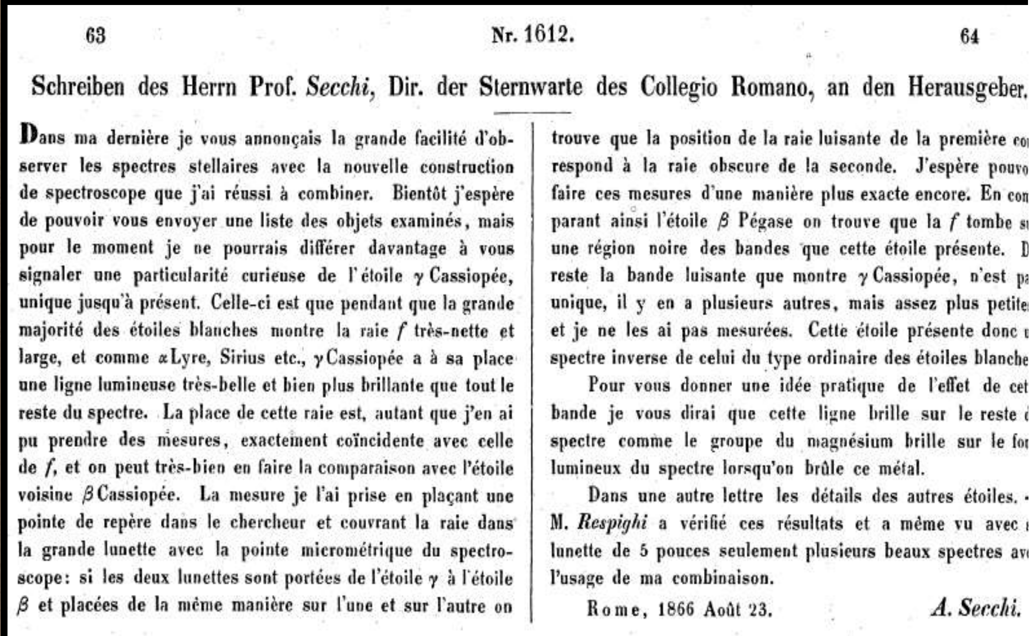
Ernst Pollmann
International Working Group ASPA
Active SPectroscopy in Astronomy
http://www.astrospectroscopy.de


γ Cas



Father Pietro Angelo Secchi
Jesuit, physicist and astronomer

As head of the Vatican Observatory, he explored spectra of numerous stars from 1867 and became a pioneer of spectral analysis



63 Nr. 1612. 64

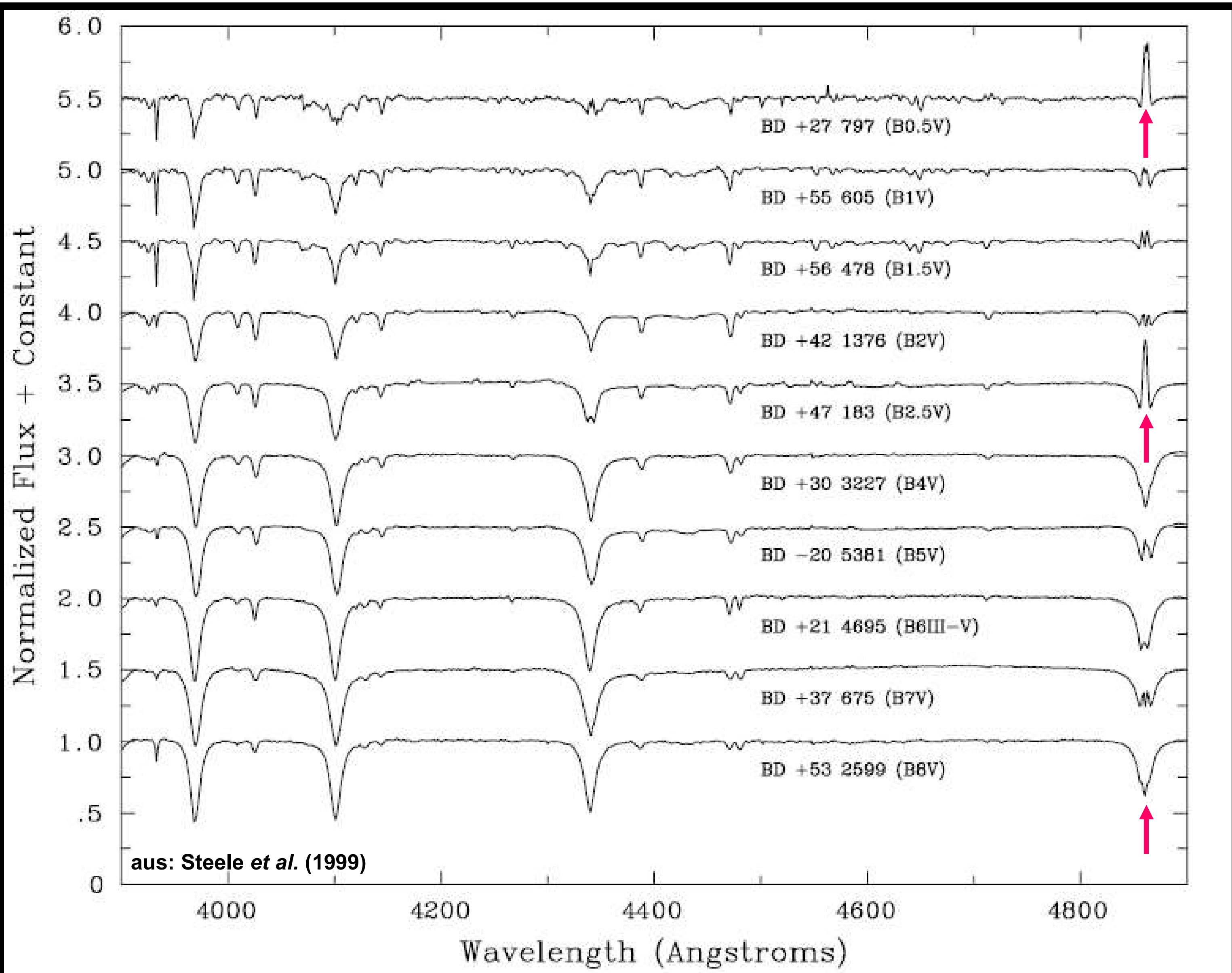
Schreiben des Herrn Prof. *Secchi*, Dir. der Sternwarte des Collegio Romano, an den Herausgeber.

Dans ma dernière je vous annonçais la grande facilité d'observer les spectres stellaires avec la nouvelle construction de spectroscope que j'ai réussi à combiner. Bientôt j'espère de pouvoir vous envoyer une liste des objets examinés, mais pour le moment je ne pourrais différer davantage à vous signaler une particularité curieuse de l'étoile γ Cassiopée, unique jusqu'à présent. Celle-ci est que pendant que la grande majorité des étoiles blanches montre la raie f très-nette et large, et comme α Lyre, Sirius etc., γ Cassiopée a à sa place une ligne lumineuse très-belle et bien plus brillante que tout le reste du spectre. La place de cette raie est, autant que j'en ai pu prendre des mesures, exactement coïncidente avec celle de f, et on peut très-bien en faire la comparaison avec l'étoile voisine β Cassiopée. La mesure je l'ai prise en plaçant une pointe de repère dans le chercheur et couvrant la raie dans la grande lunette avec la pointe micrométrique du spectroscope: si les deux lunettes sont portées de l'étoile γ à l'étoile β et placées de la même manière sur l'une et sur l'autre on trouve que la position de la raie luisante de la première co respond à la raie obscure de la seconde. J'espère pouvo faire ces mesures d'une manière plus exacte encore. En com parant ainsi l'étoile β Pégase on trouve que la f tombe s une région noire des bandes que cette étoile présente. D reste la bande luisante que montre γ Cassiopée, n'est pa unique, il y en a plusieurs autres, mais assez plus petite et je ne les ai pas mesurées. Cette étoile présente donc u spectre inverse de celui du type ordinaire des étoiles blanche

Pour vous donner une idée pratique de l'effet de cet bande je vous dirai que cette ligne brille sur le reste d spectre comme le groupe du magnésium brille sur le fo lumineux du spectre lorsqu'on brûle ce métal.

Dans une autre lettre les détails des autres étoiles. M. *Respighi* a vérifié ces résultats et a même vu avec lunette de 5 pouces seulement plusieurs beaux spectres av l'usage de ma combinaison.

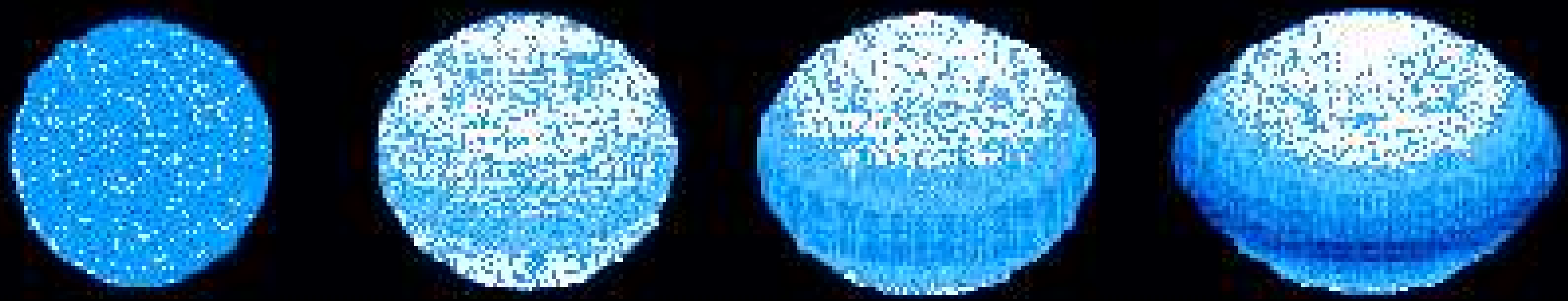
Rome, 1866 Août 23. *A. Secchi.*



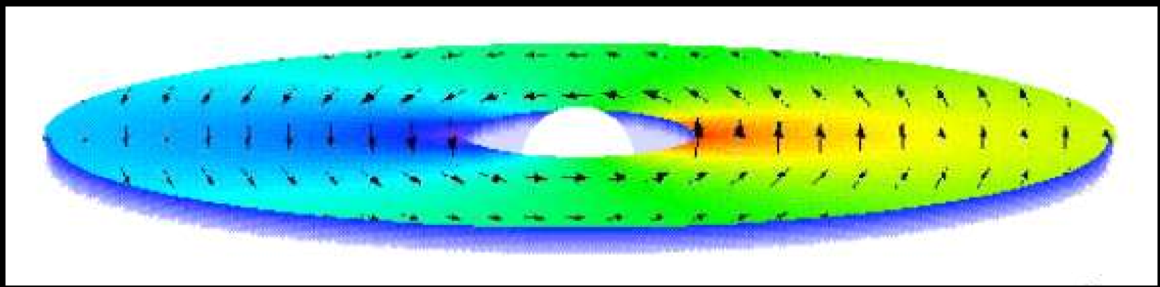
Example spectra of B stars of the main sequence with the Balmer lines
Hε (3970), **Hδ** (4101), **Hγ** (4341) **und Hβ** (4861)

Emission in Hβ turns these B stars into Be stars

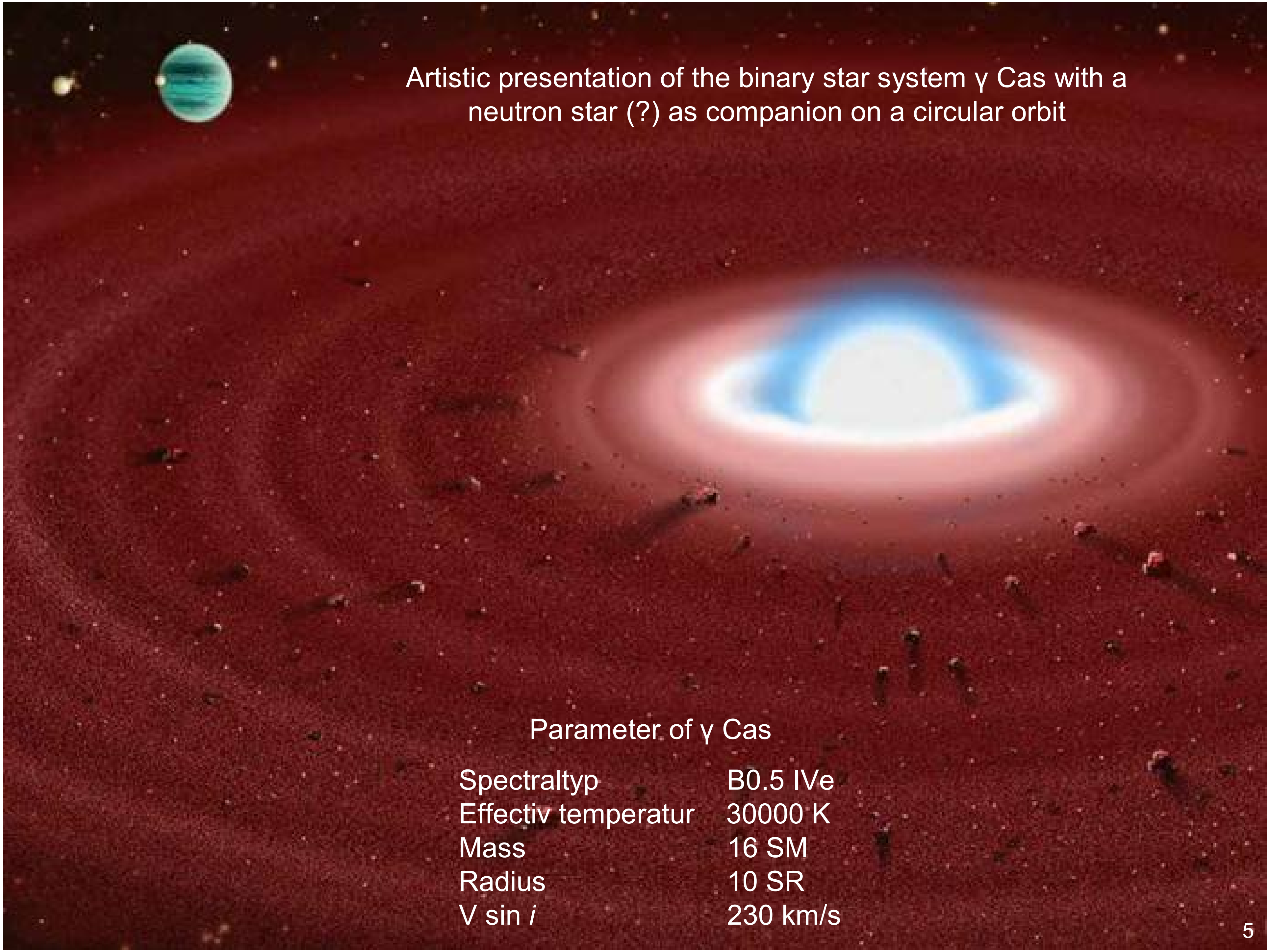
Deformation in the equatorial plane with increasing rotational velocity & centrifugal force



Vrot = 0 **Vrot >** **Vrot ~ 500 km/s**



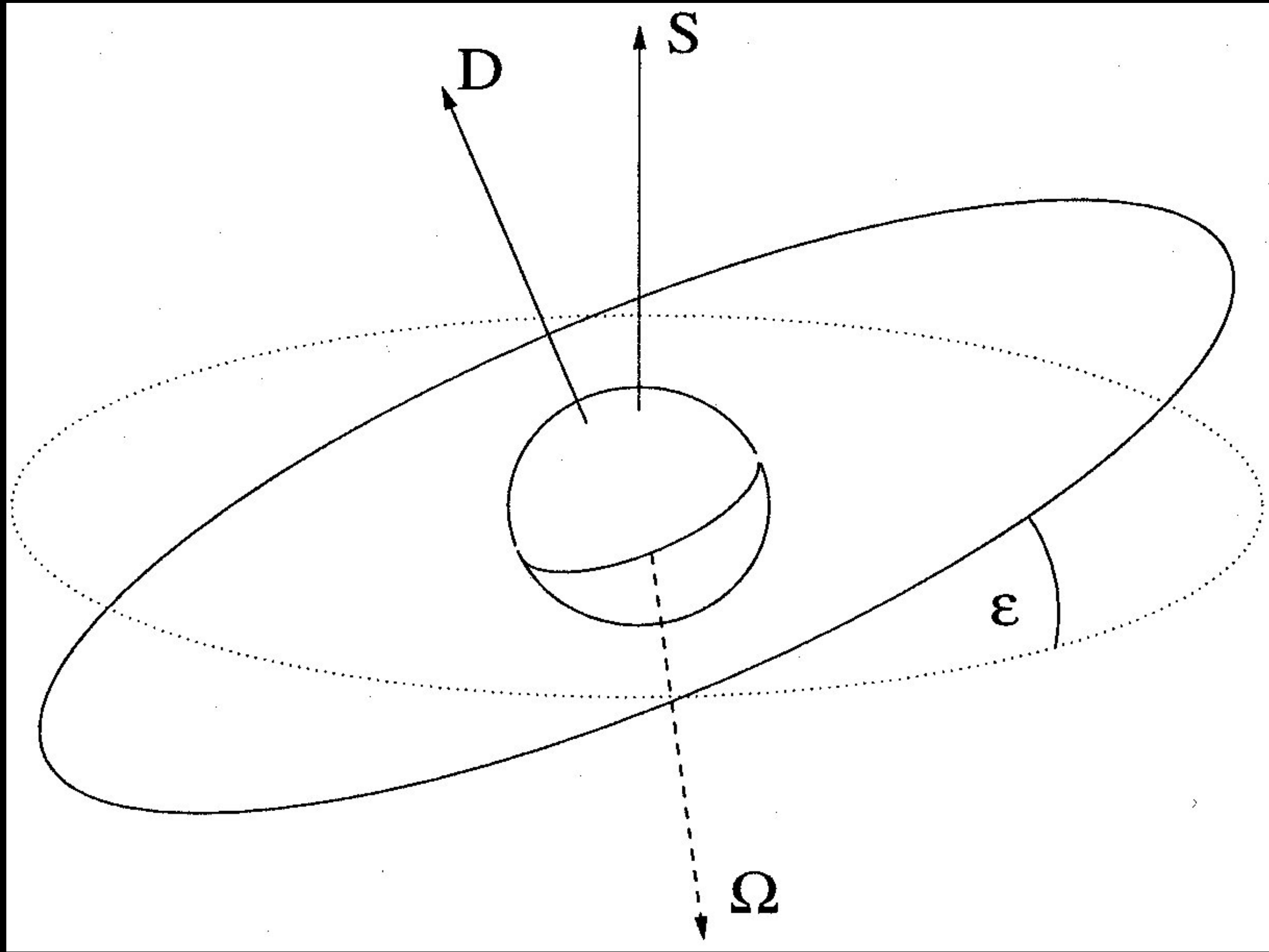
Circumstellar disk of gas in the equatorial plane as a result of high rotational speed & centrifugal force



Artistic presentation of the binary star system γ Cas with a neutron star (?) as companion on a circular orbit

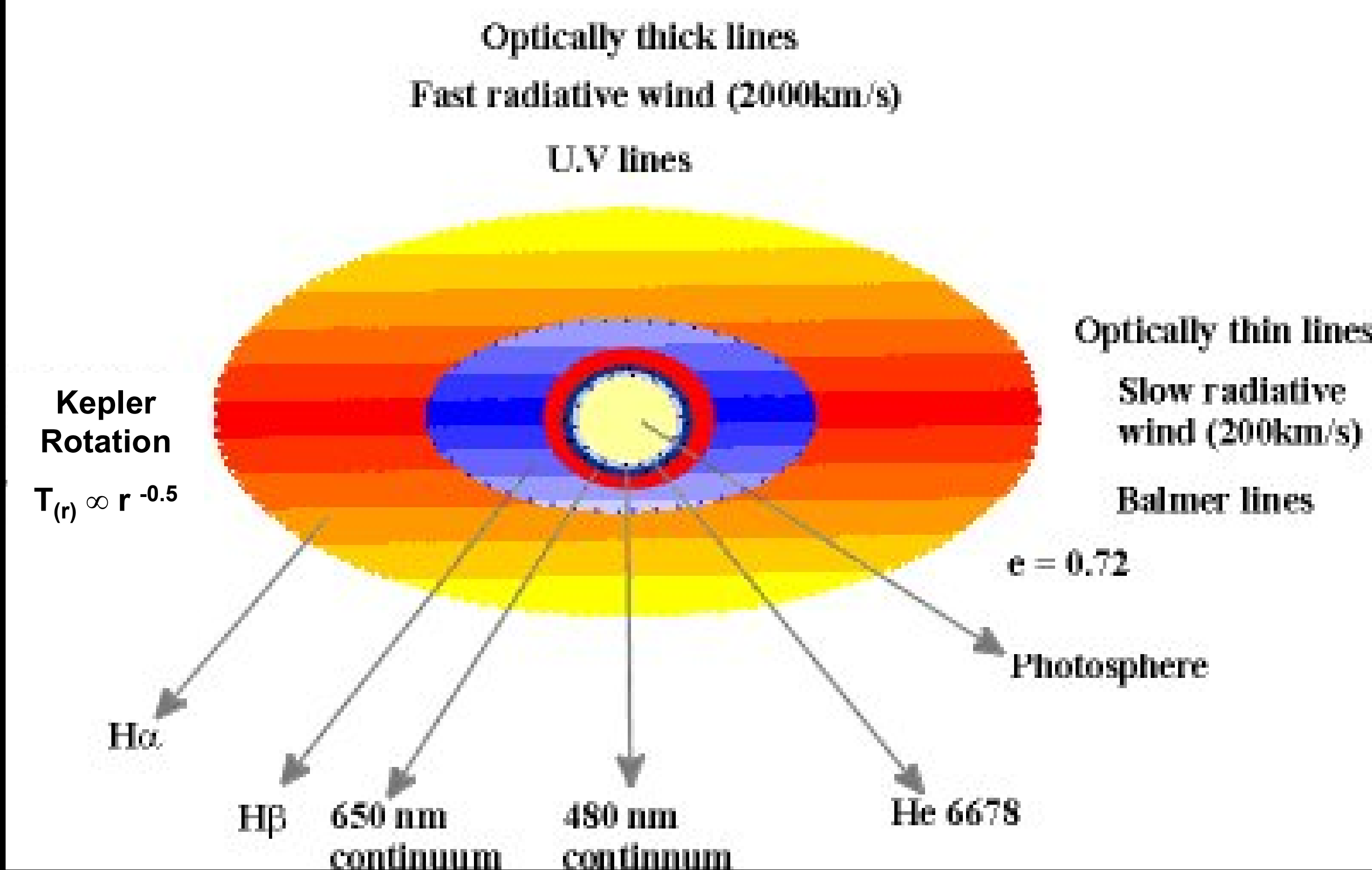
Parameter of γ Cas

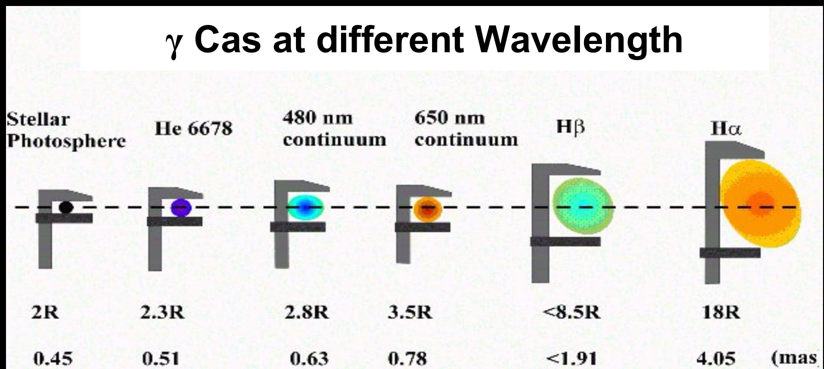
Spectraltyp	B0.5 IVe
Effectiv temperatur	30000 K
Mass	16 SM
Radius	10 SR
V sin *i*	230 km/s

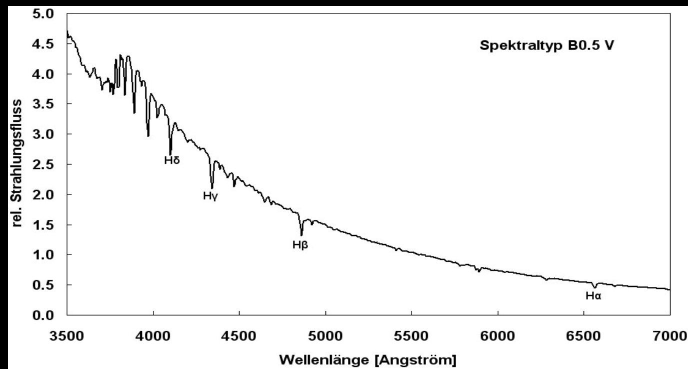


Schematic representation of the inclined circumstellar disk.
ε is the angle of inclination of 45 ° of the disk with respect to the equatorial plane of the star. Ω is the line of nodes. S indicates the stellar axis of rotation and D the axis of rotation of the disk

Today's model idea of γ Cas



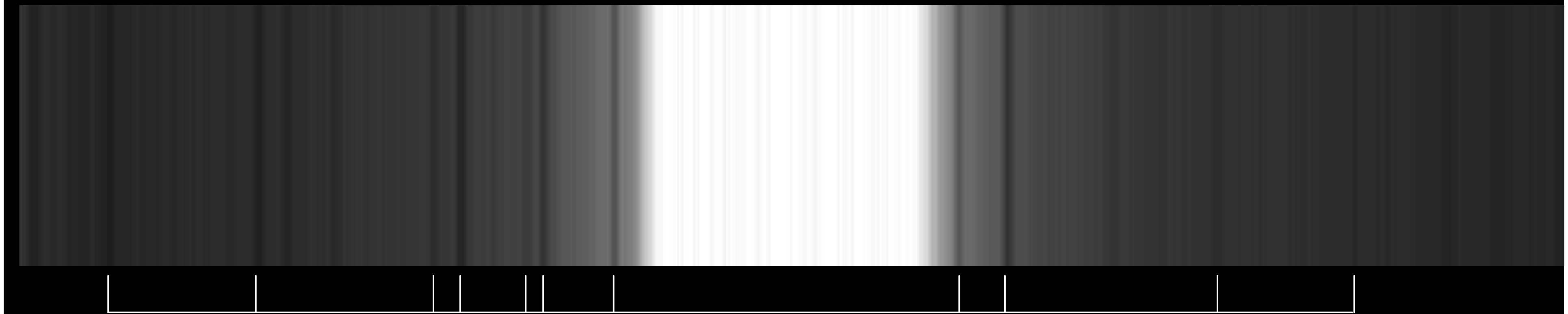




Hα raw spectrum of γ Cas

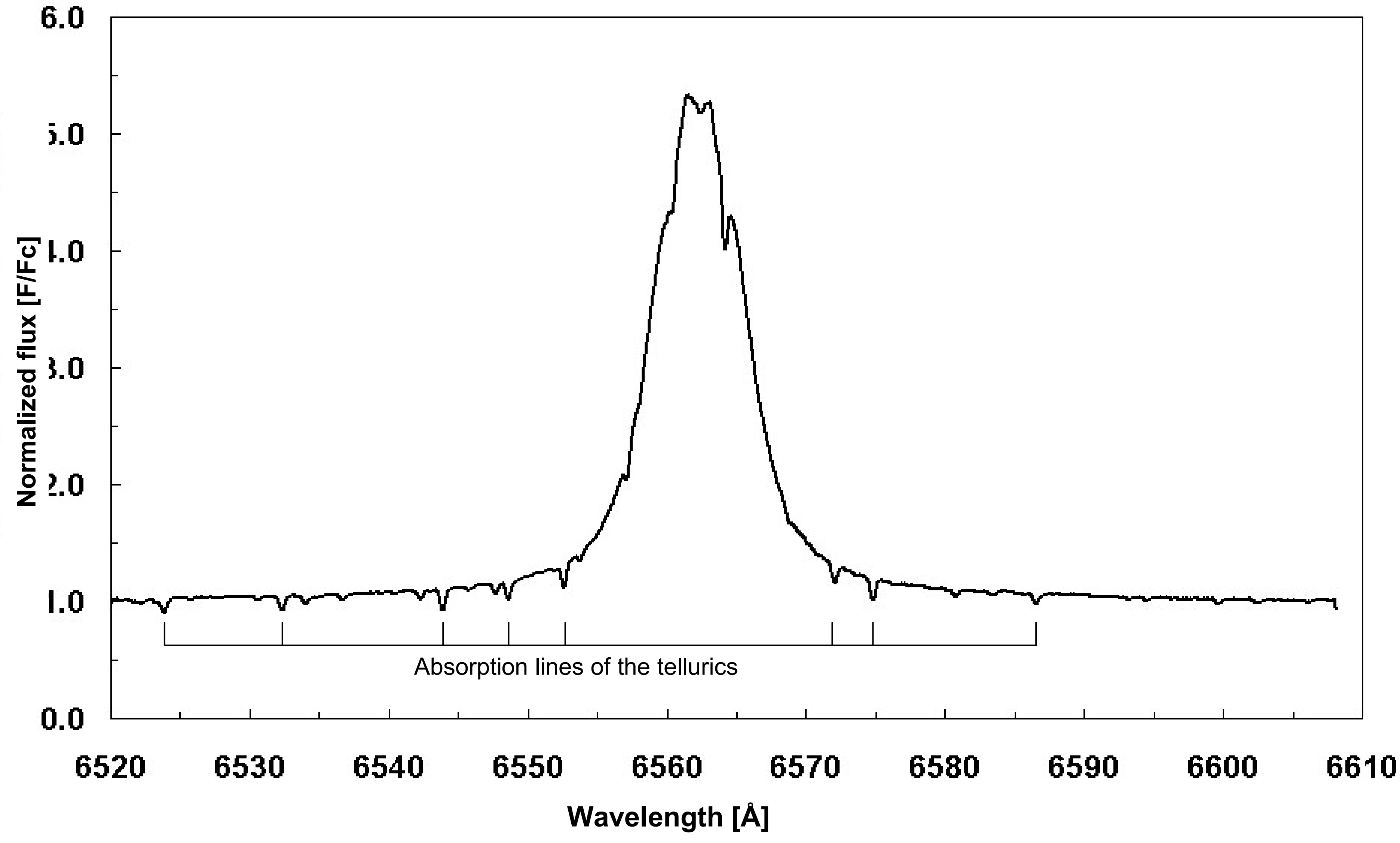
Spectrograph LHIRES III; Telescope C14; CCD-Camera NOVA 402Me

Hα Emission 6563 Å

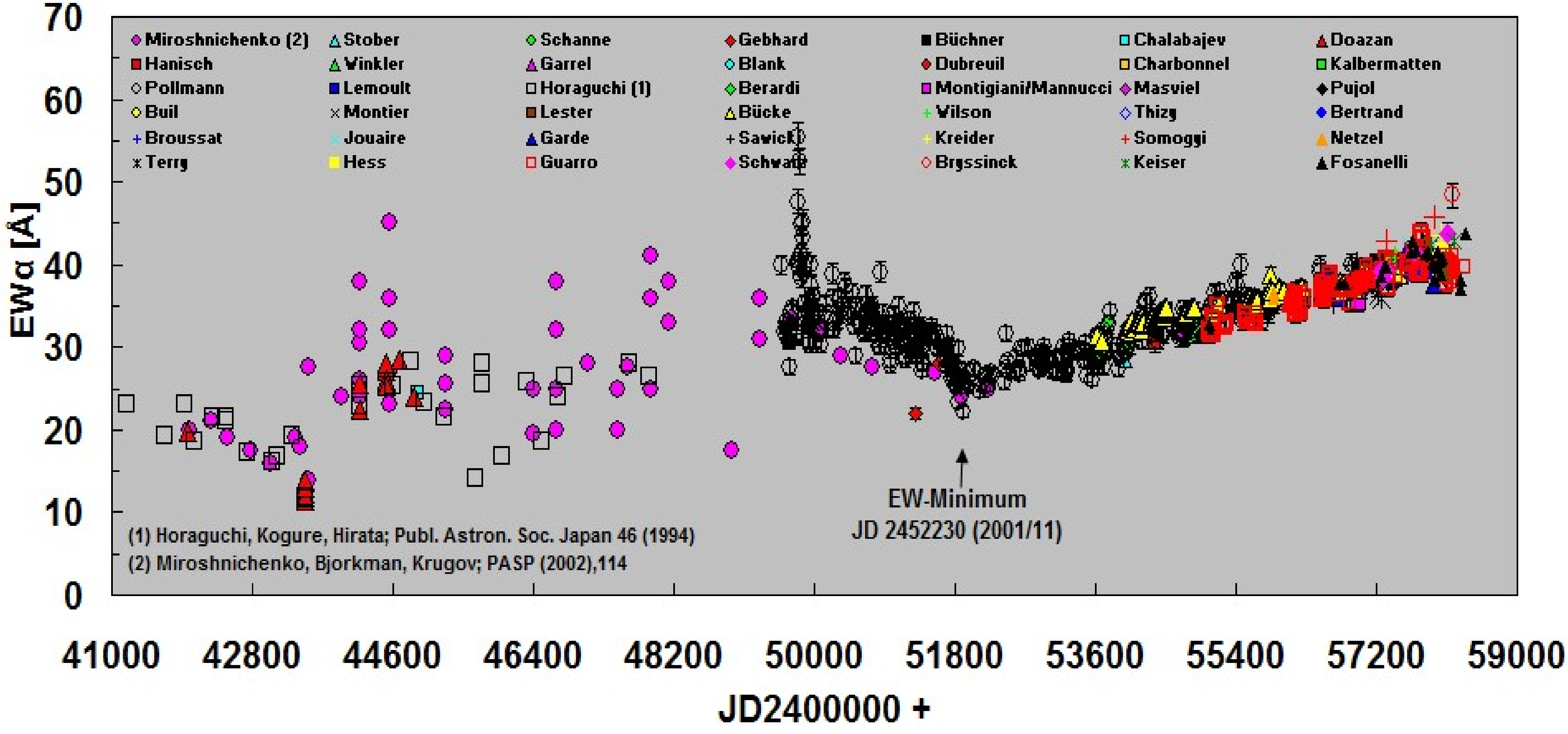


Absorption lines of the atm. water vapour (tellurics)

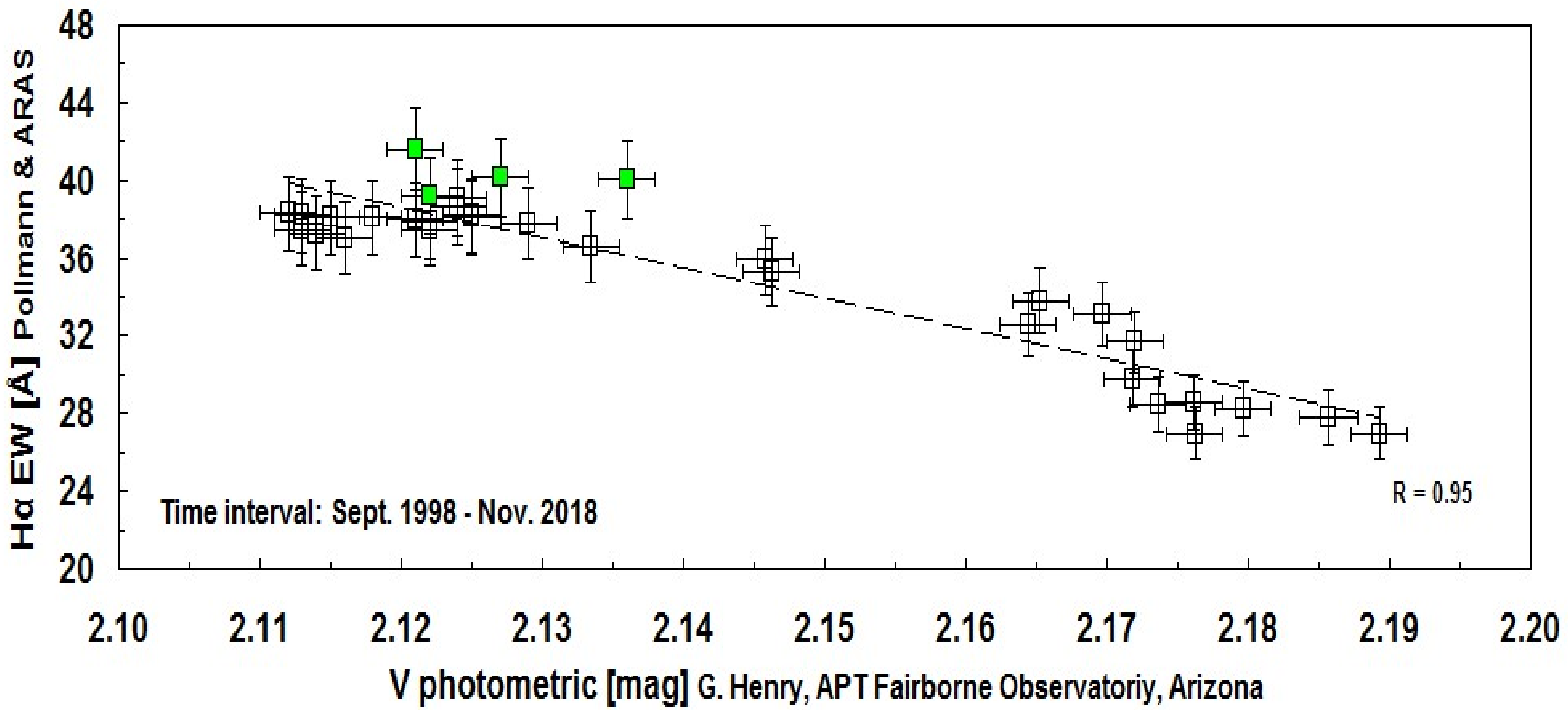
Hα Spektrum des Be-Sterns γ Cas
Spektrograph LHIRES III / Teleskop C14

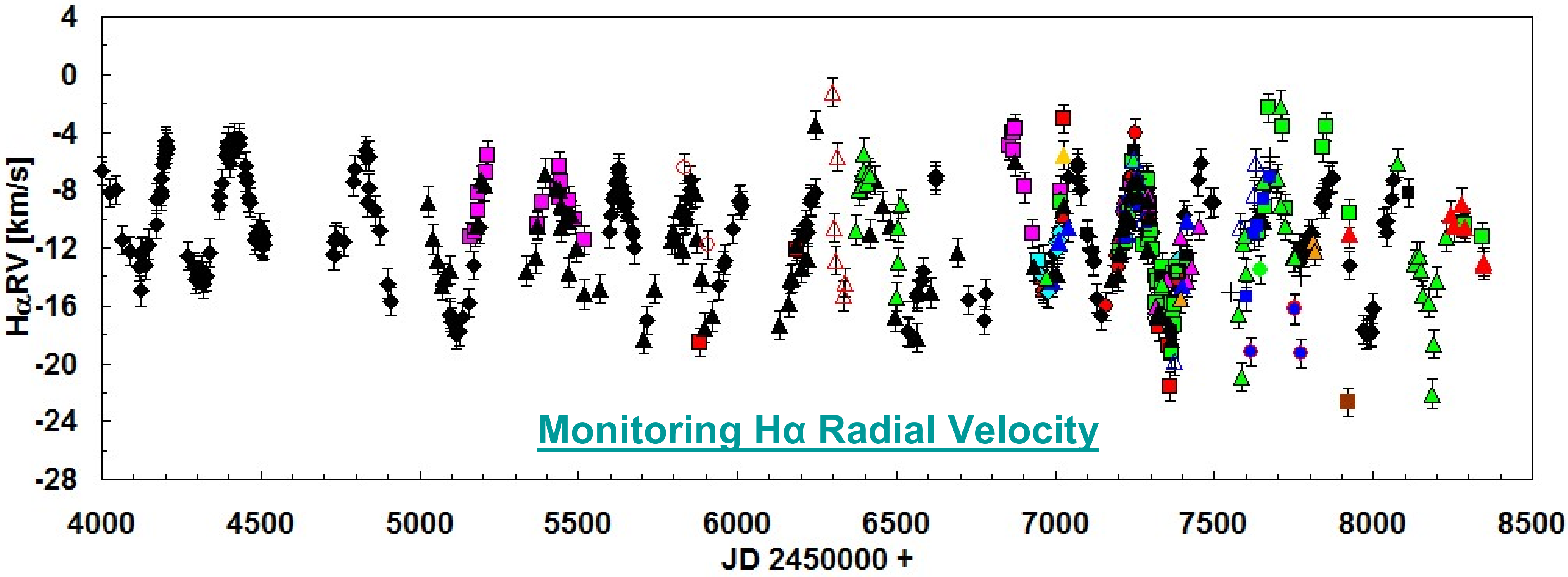


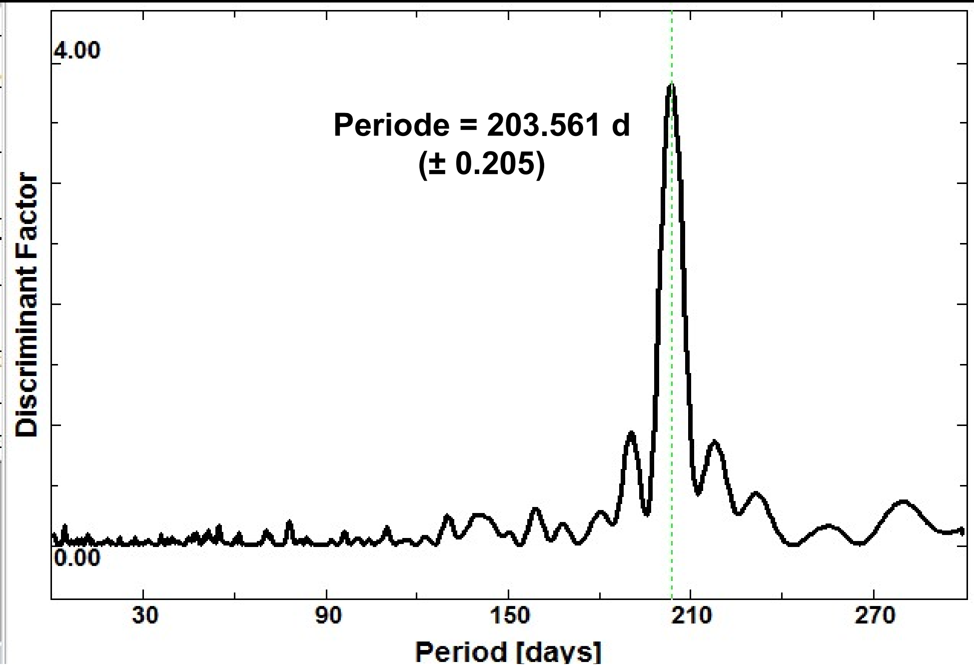
Long-term monitoring of the Hα emission line strength

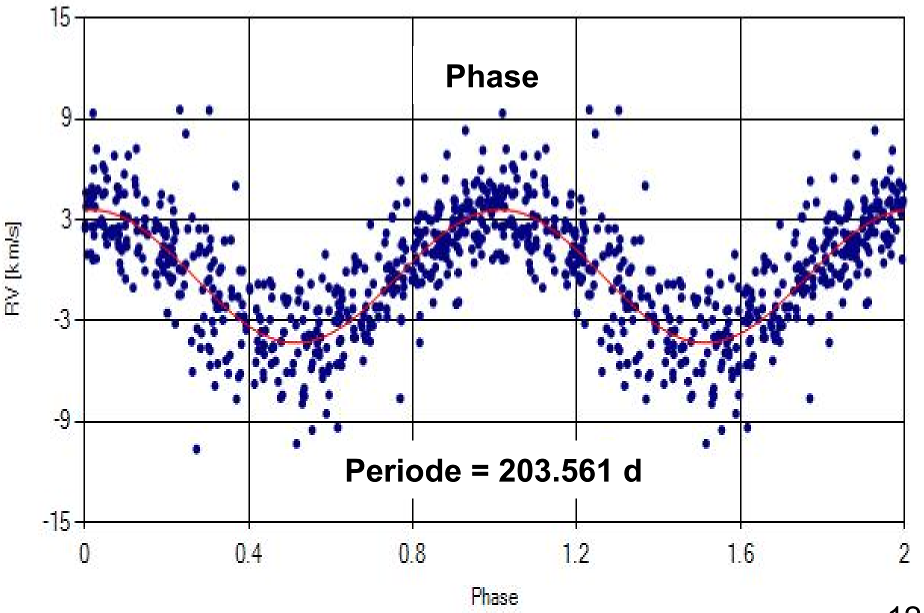


Relationship between the Hα emission strength (EW) and visual brightness Vmag of the star

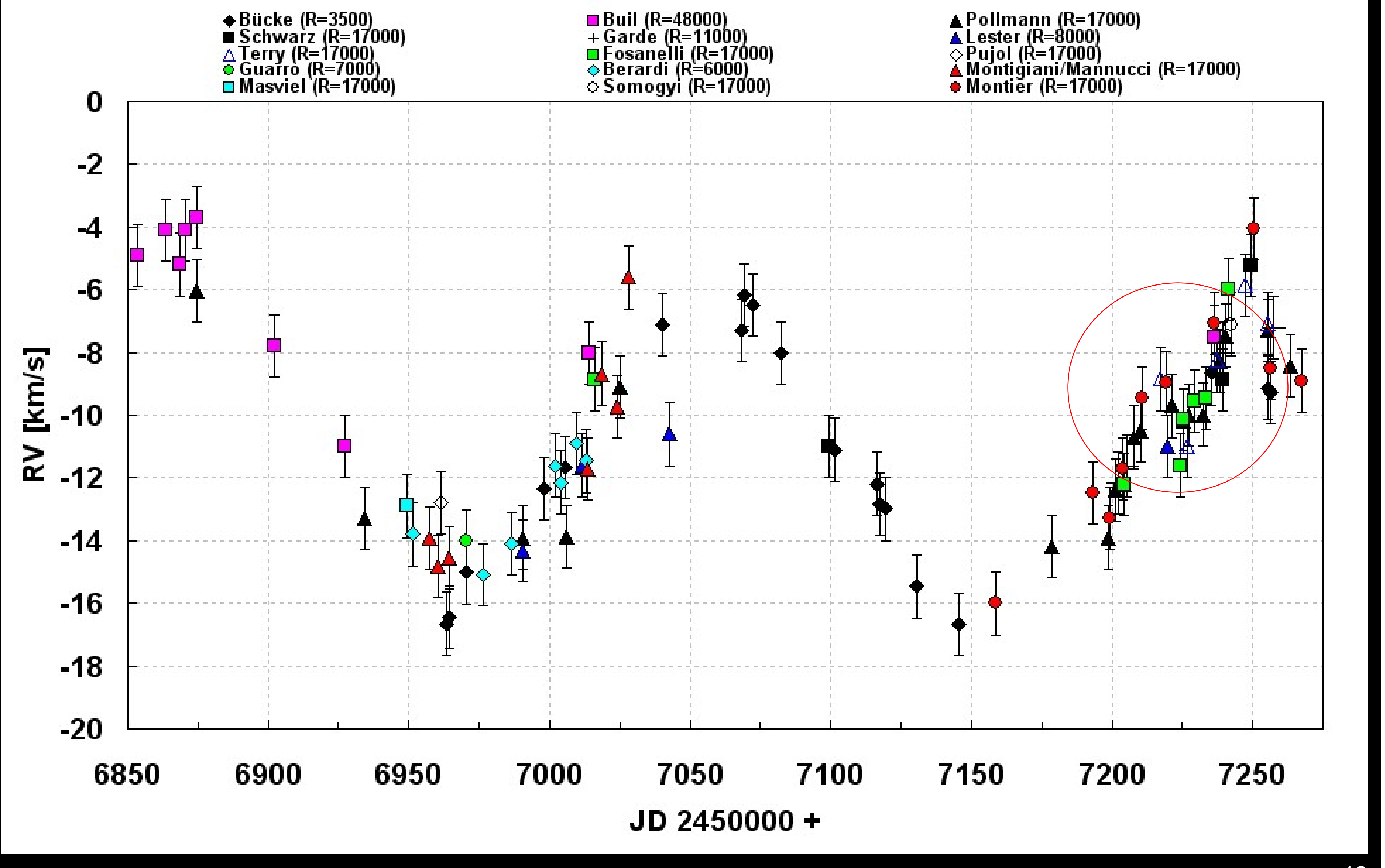



Monitoring Hα Radial Velocity
HαRV [km/s]
JD 2450000 +

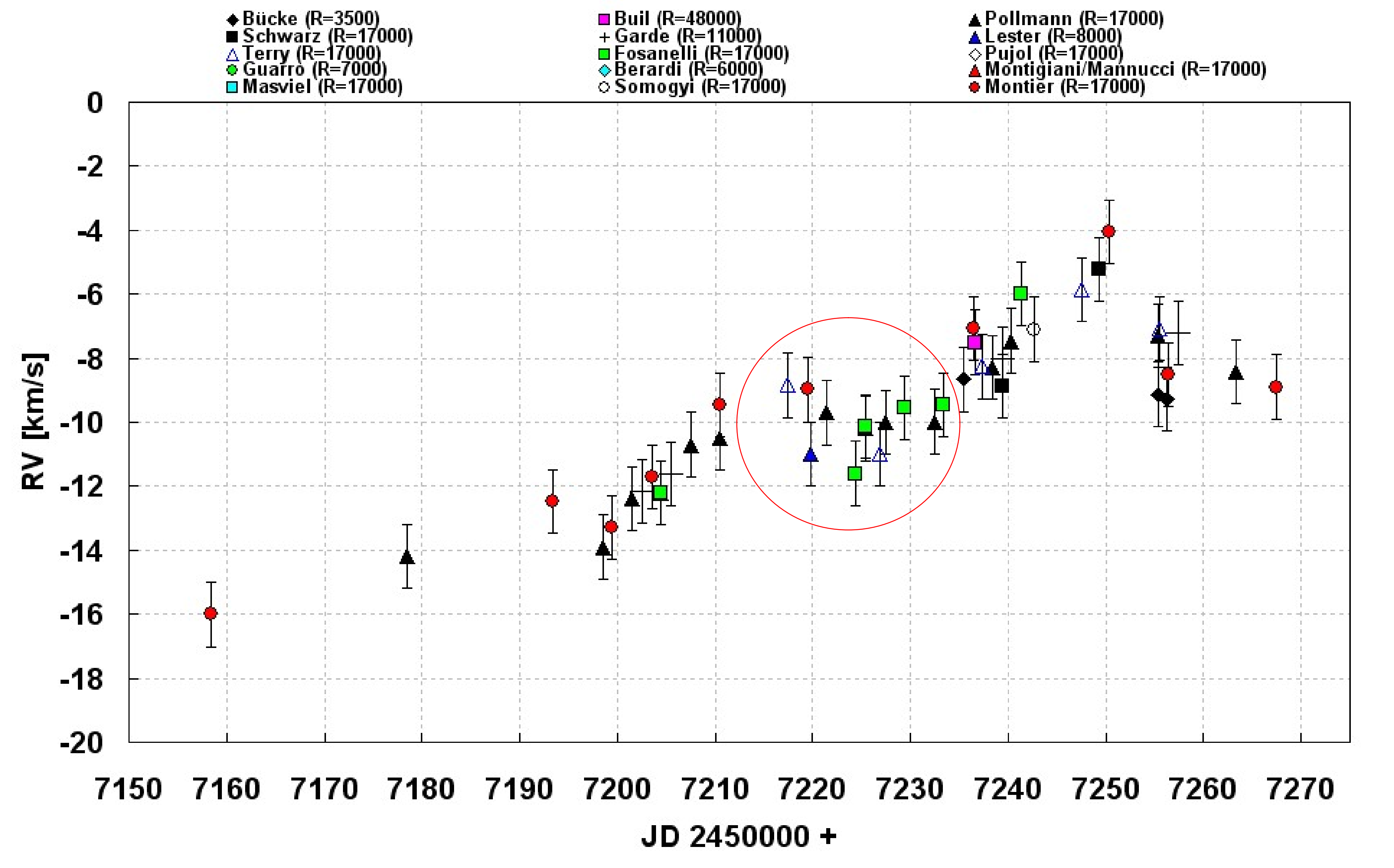

Periode = 203.561 d
(± 0.205)
Discriminant Factor
Period [days]


Phase
Periode = 203.561 d
RV [km/s]
Phase

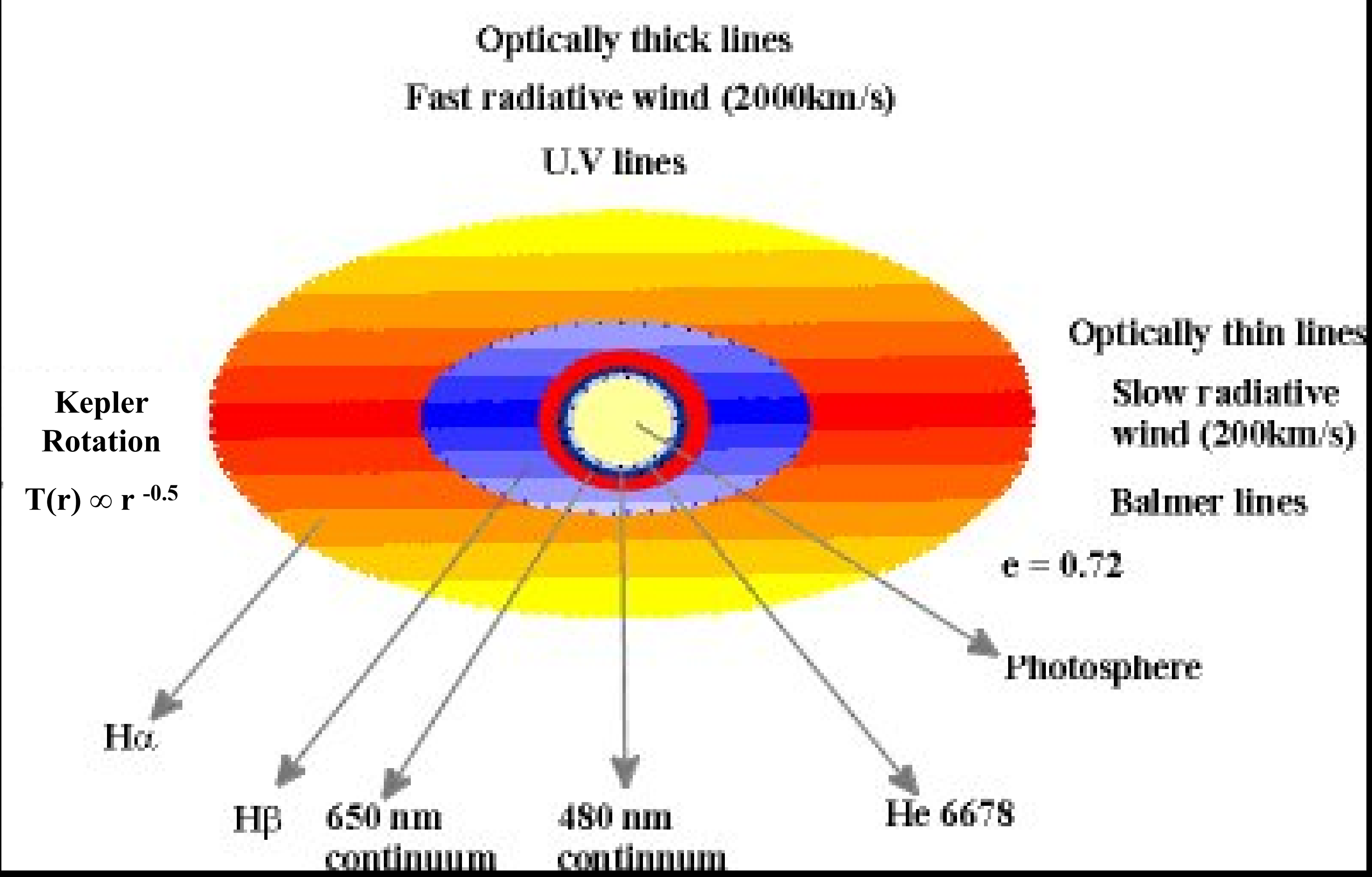
Disturbance of the sinusoidal progress around 7200 to 7250

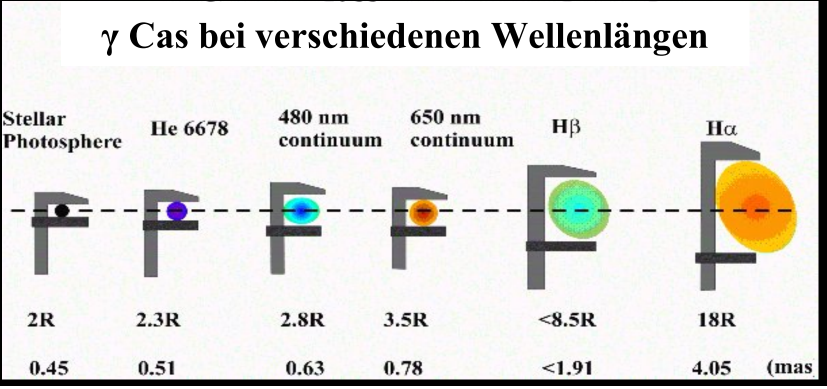


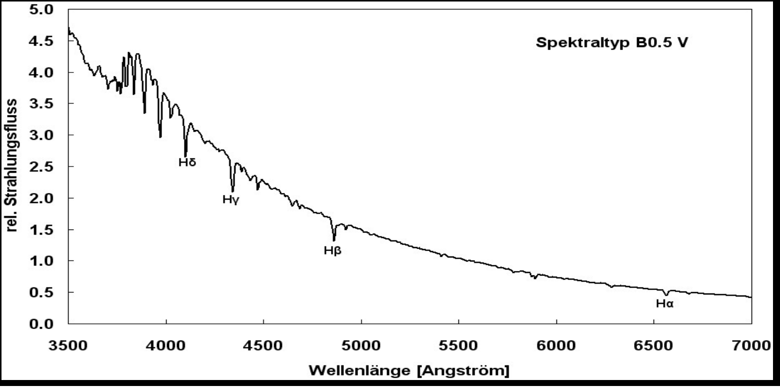
Enlargement of the Disturbance around 7200 to 7250



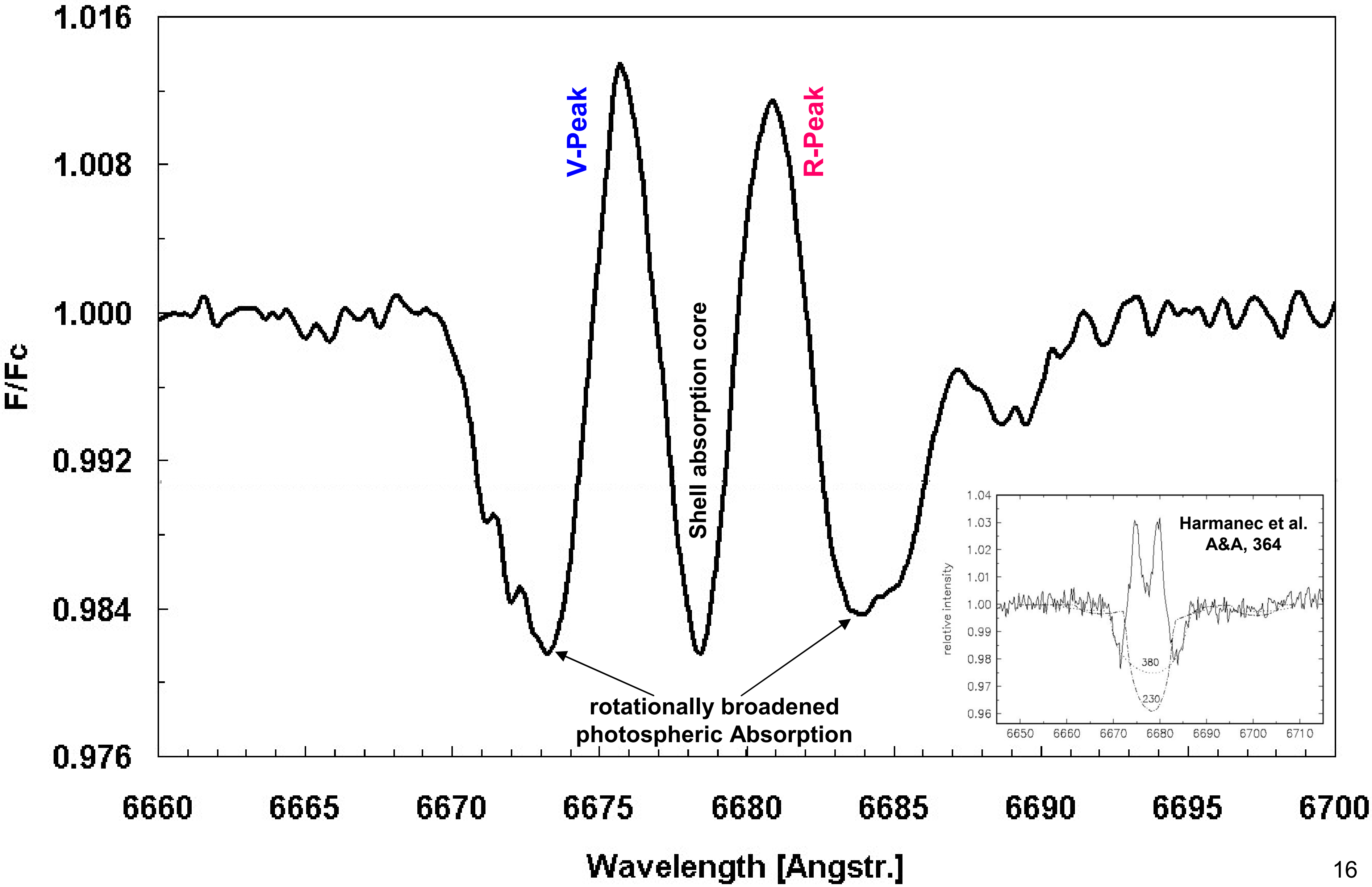
Heutige Modellvorstellung von γ Cas

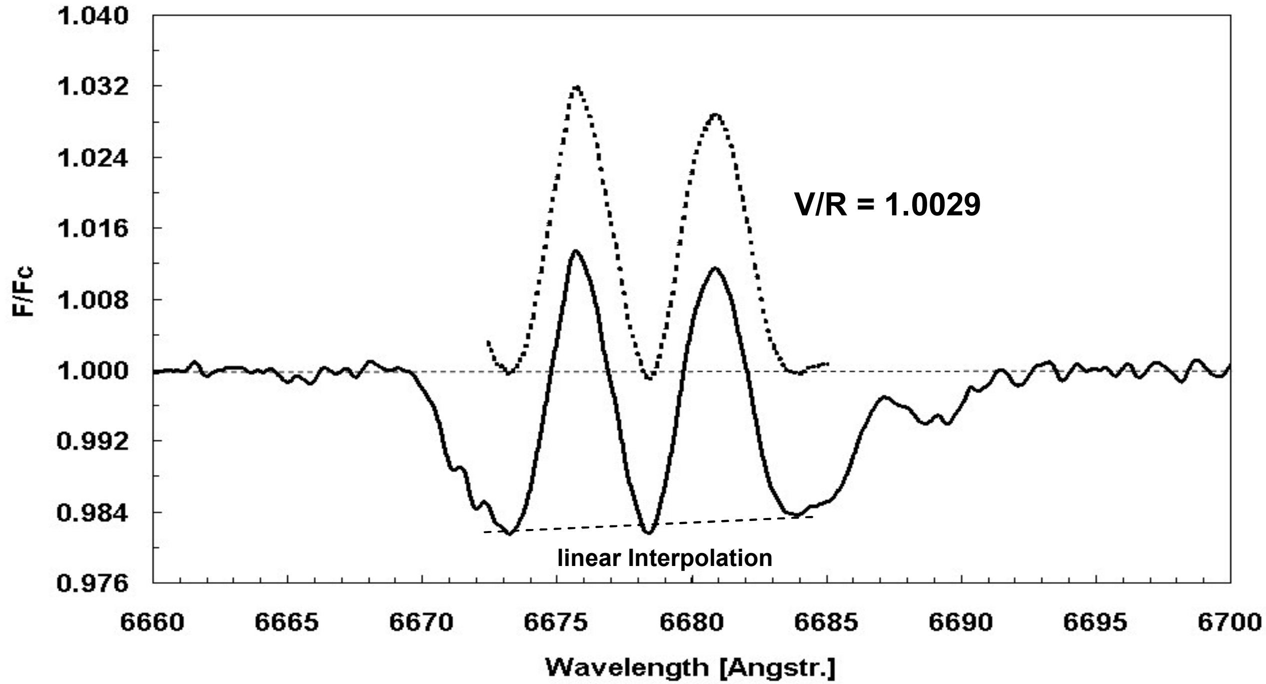




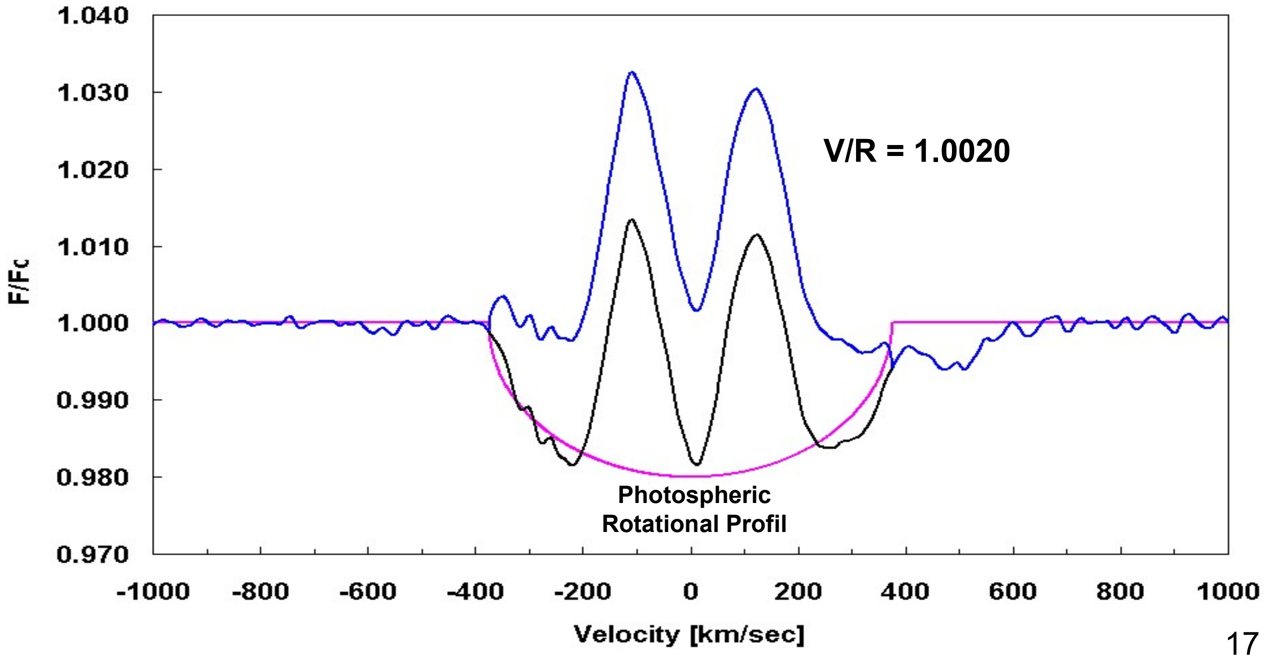


Spectrum of the He I 6678 double peak emission at γ Cas



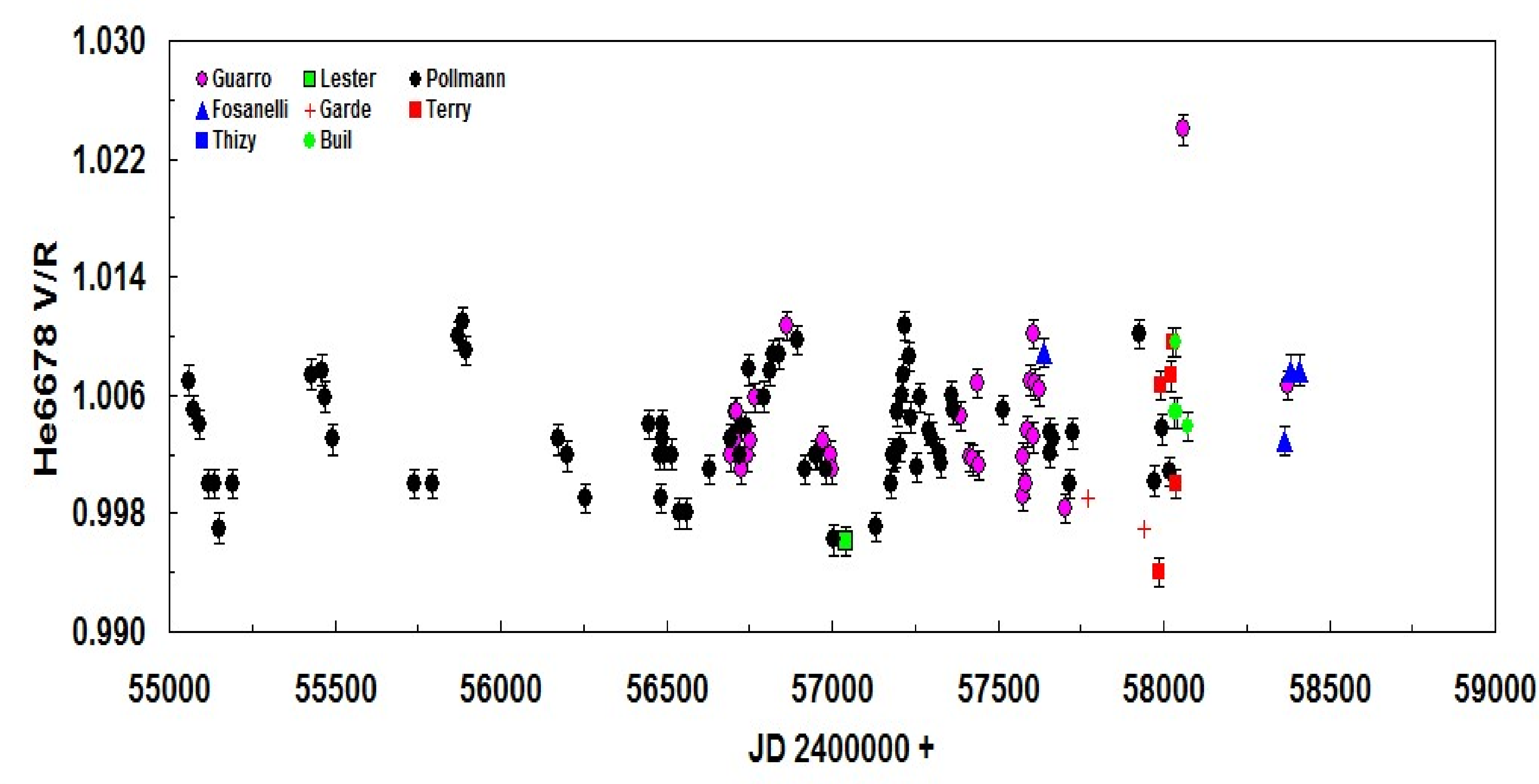


1.040
1.032
1.024
1.016
1.008
1.000
0.992
0.984
0.976
F/Fc
V/R = 1.0029
linear Interpolation
6660
6665
6670
6675
6680
6685
6690
6695
6700
Wavelength [Angstr.]

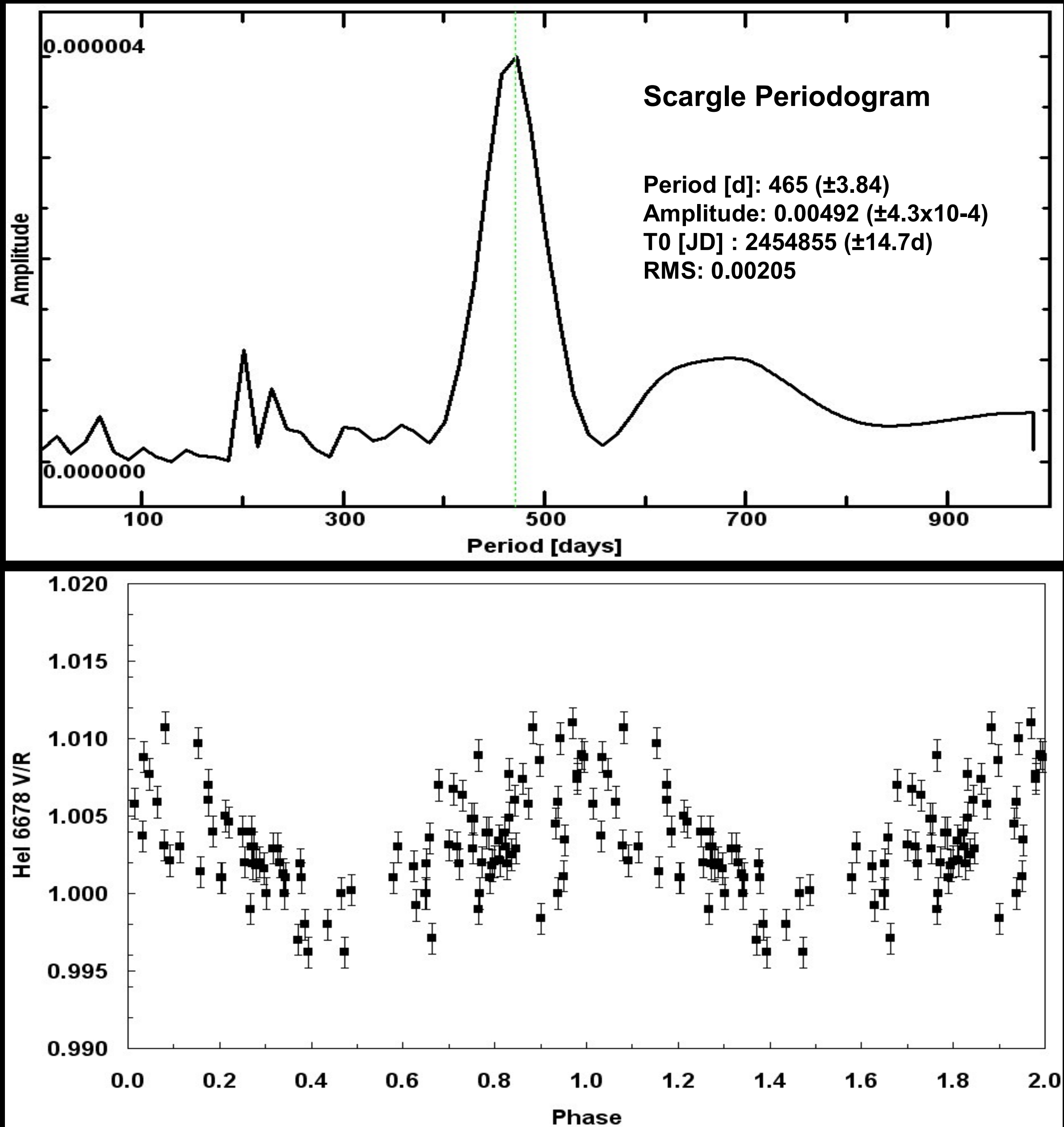


1.040
1.030
1.020
1.010
1.000
0.990
0.980
0.970
F/Fc
V/R = 1.0020
Photospheric
Rotational Profil
-1000
-800
-600
-400
-200
0
200
400
600
800
1000
Velocity [km/sec]

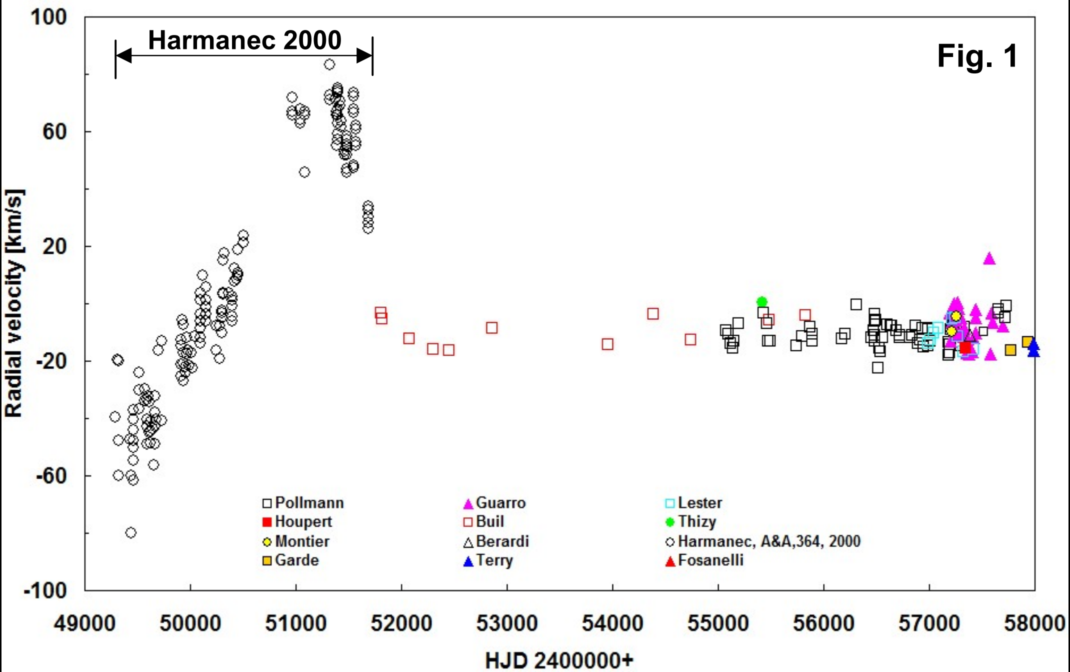
V/R Monitoring of HeI 6678 double peak emission since 08/2009 until now

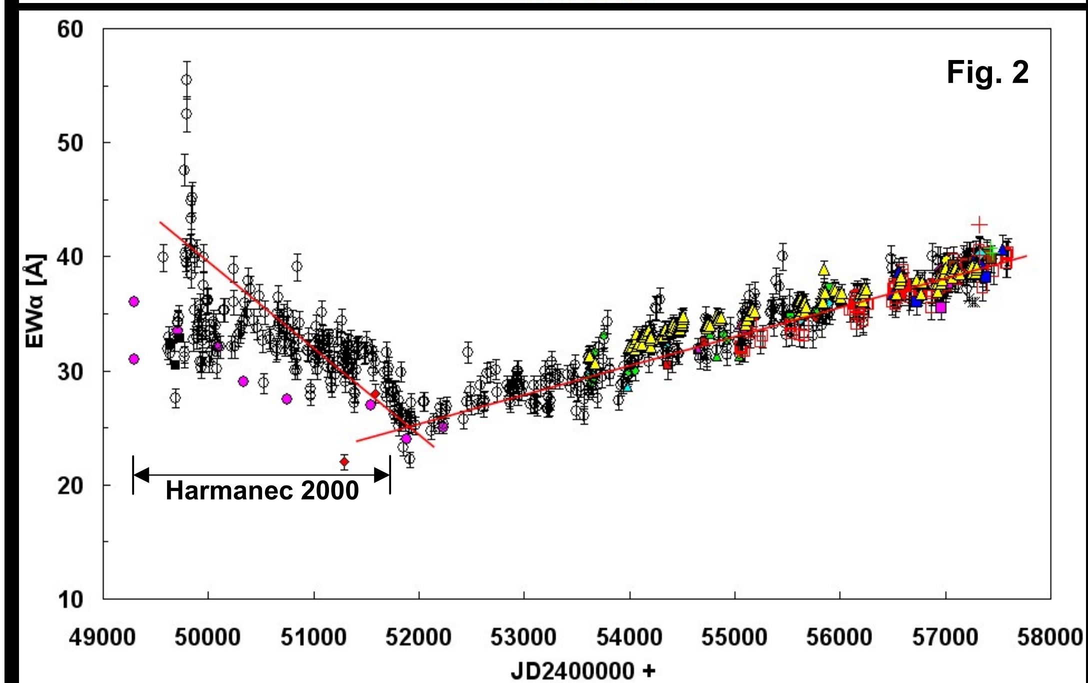


Period analysis of the V/R ratio of the HeI 6678 emission



Long-term HeI 6678 Radial Velocity





The enormous change of radial velocity within the H2000 time section (Fig. 1) leads to the question of the responsible causes

A comparison to the Hα-EW of the same time section seems to be therefore of interest. Fig. 2 shows for this time section an EW decrease of ~ 45% from the original 40-45Å to ~ 25 Å.

The Hα EW is an indicator of the total mass of the gas disc around the primary star, which rotates counterclockwise together with the photosphere-near Helium ring (HeI 6678) around the primary.

3. Kepler´s law: M1 * a1 = M2 * a2

Mass loss of the disk of the half of its original mass in this binary system, with the masses M1 for the companion and M2 for the primary plus disk would mean that also the distance a2 of the primary plus disk to the common center of gravity, has to change.

That´s why a change of the velocity vector has to expect. Exactly this is to see in H2000 measurements until to the maximum.

From ~ JD 2451800 however, a different relationship would apply. From this point, the EW shows a steady increase which corresponds to a growth of the disc.

However, since the disk is fed by mass loss of the primary star with otherwise constant mass M2, this process has no consequences of the change of the distance a2 to the common center of gravity and of the (radial) velocity vector.

…ready for
observation?