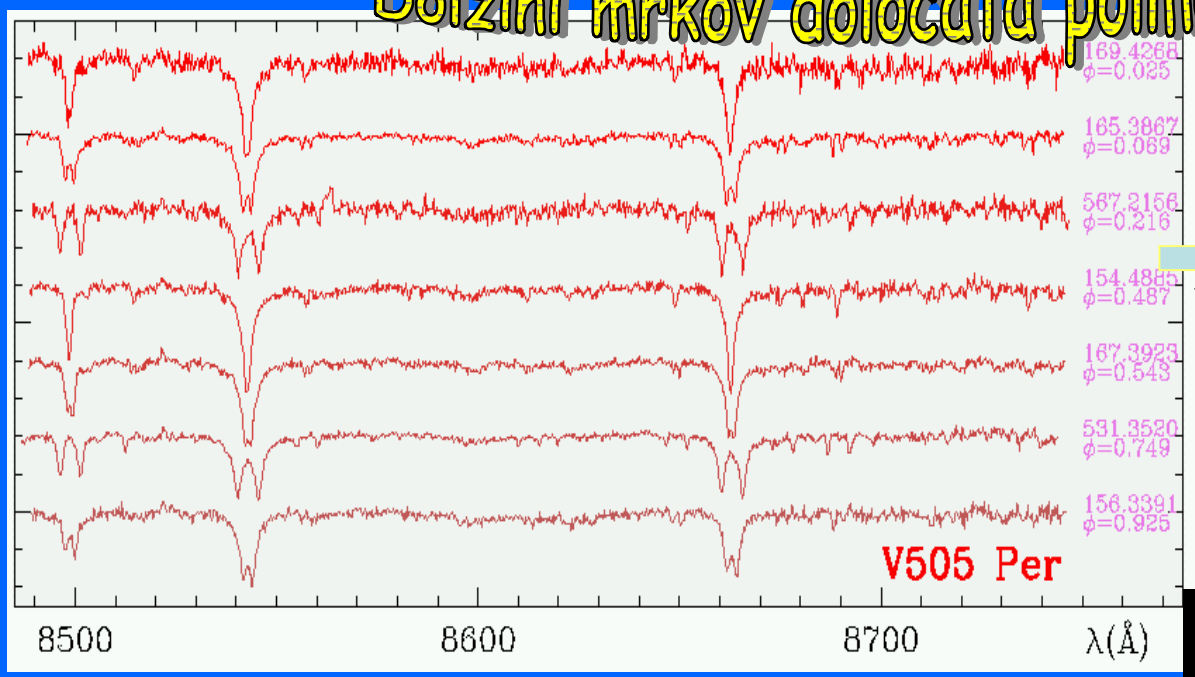
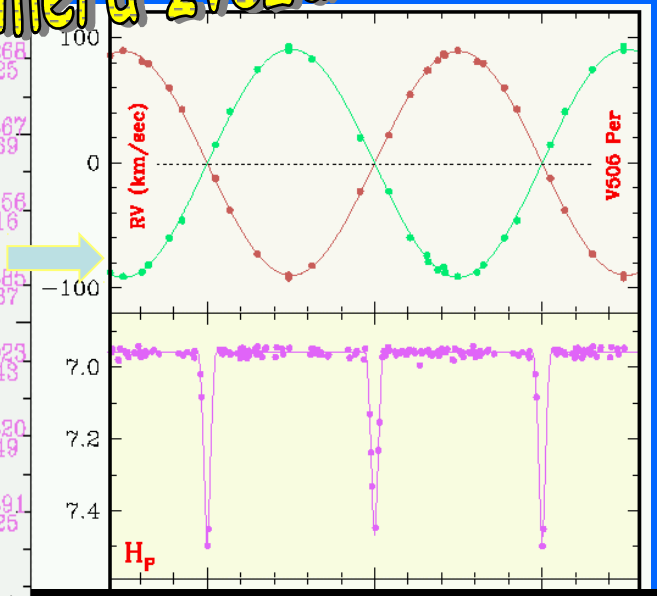
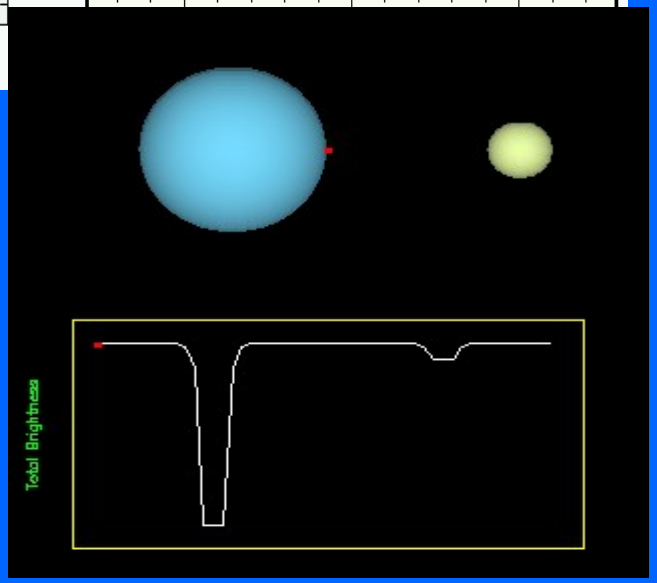
Prekrivalne dvojne zvezde

Dolžini mrkov določata polmera zvezd







a = 15.06 +/- 0.08 R_o

M_1 = 1.30 +/- 0.02 M_o
M_2 = 1.28 +/- 0.02 M_o

R_1 = 1.40 +/- 0.02 Ro
R_2 = 1.14 +/- 0.03 Ro

T_1 = 6460 +/- 50 K

T_2 = 6415 +/- 50 K

razdalja: 60 +/- 3 pc Asiago/GAIA
66 +/- 4 pc Hipparcos

Spectroscopy of A0620 − 00: the mass of the black hole and an image of its accretion disc

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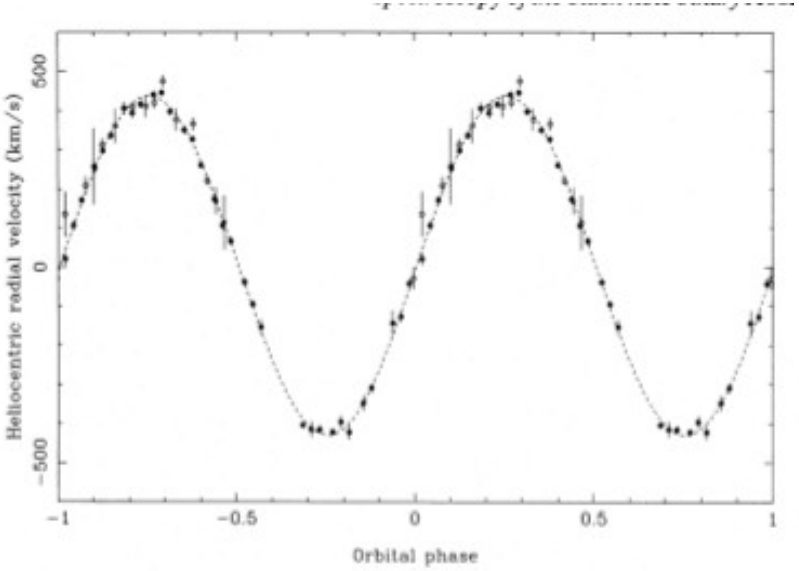


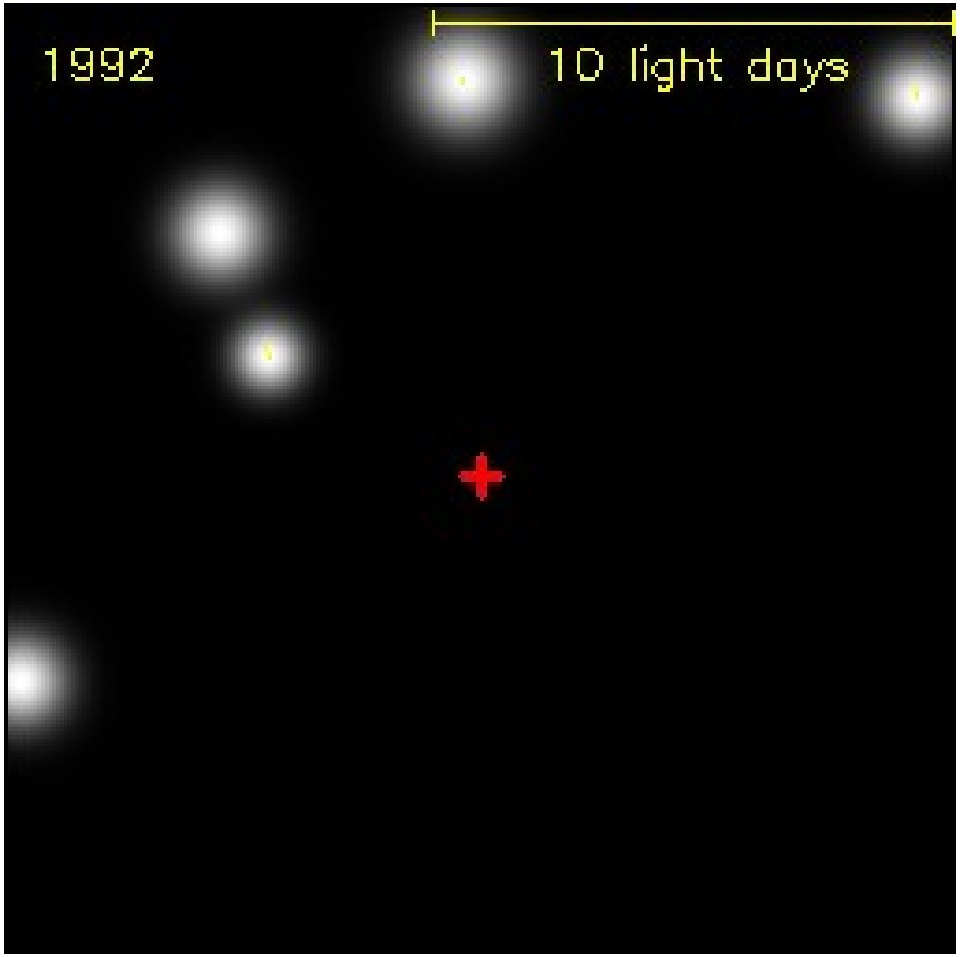
ABSTRACT

We present spectra of the black hole binary A0620 − 00 taken at Hα and Hβ to study the distribution of emission-line flux from its accretion disc. Using the spectra of Hα, we have measured the K-type companion star's radial velocity semi-amplitude and rotational broadening to be $K_2 = 433 \pm 3$ km s^{-1} and $v \sin i = 83 \pm 5$ km s^{-1}. Accounting for the Roche-lobe geometry of the companion, the rotational broadening gives the mass ratio $q = M_2/M_1 = 0.067 \pm 0.01$. The disc contributes 6 ± 3 per cent of the light at Hα and 17 ± 3 per cent at Hβ, with the K star providing the rest. The masses of the compact object and K star derived from our values of K_2 and q are $M_1 = (3.09 \pm 0.09) \sin^{-3} i$ M$_\odot$ and $M_2 = (0.21 \pm 0.04) \sin^{-3} i$ M$_\odot$. Applying a constraint upon the orbital inclination, i, from an eclipse found in an earlier study, we obtain 2σ ranges on the masses of $3.30 < M_1 < 4.24$ M$_\odot$ and $0.15 < M_2 < 0.38$ M$_\odot$. The lower limit on the mass of the compact object is higher than the maximum mass of a rotating neutron star based upon equations of state for nuclear material.

Subtraction of the correctly broadened template star removes all lines other than a line at 6708 Å which we identify as Li I 6707.8 Å, which has recently been found in another black hole binary, V404 Cyg. The equivalent width of this line in A0620 − 00 is 160 ± 30 mÅ compared to 290 ± 50 mÅ in V404 Cyg.

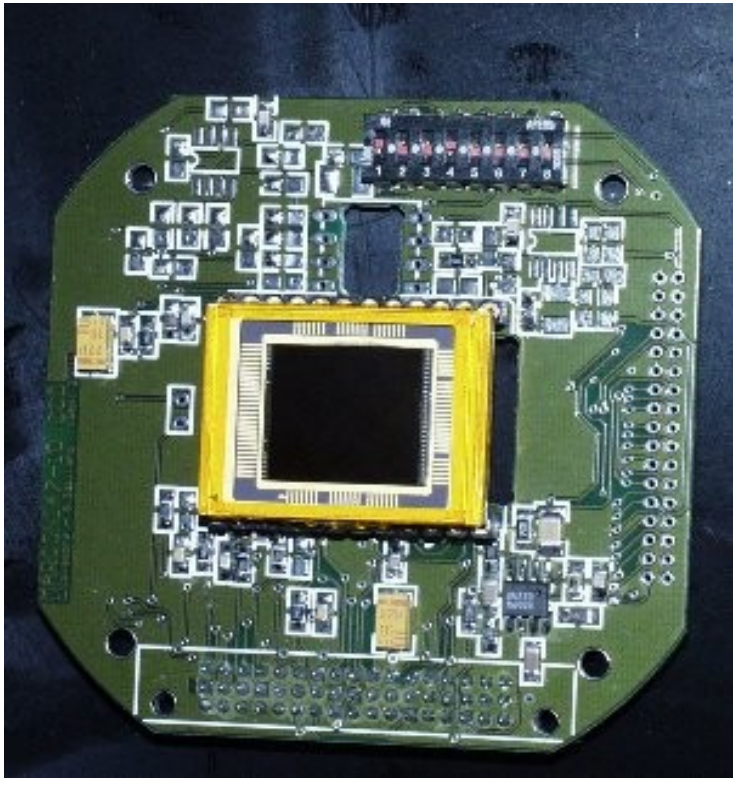
Doppler images of the Balmer lines are very similar to those of quiescent dwarf novae, with emission from the region where the gas stream hits the disc and emission from the stream itself prior to this point. The Balmer decrement steepens towards the outer edge of the disc. The impact point gives a disc radius of $\approx 0.5\,R_{L1}$, where R_{L1} is the inner Lagrangian point distance, consistent with the separation of the emission-line peaks. In general, the spectra appear to be of lower excitation than those of dwarf novae, with no He II 4686 emission, weak He I emission and Balmer emission of large equivalent width. There is thus very little ionizing radiation in the system, and a rough analysis suggests that the accretion rate on to the compact object must be less than about 4×10^{12} g s^{-1}.

Key words: accretion, accretion discs − black hole physics − binaries: close − stars: individual: A0620 − 00 − stars: rotation −X-rays: stars.


1992
10 light days

Magnitude

- navidezna magnituda
- majhne spremembe magnitude
- spreminjanje magnitude z razdaljo
- absolutna magnituda
- barvni filtri



Barve in temperature zvezd

Barvni filtri: UBVRIJKLMN

MAIN ARTICLE Johnson, H. L. 1965, ApJ 141, 923

SYSTEM DESCRIPTION

BANDS DESCRIPTION			FLUX CALIBRATION (#) [152], [153]	
band	λ_0 (μm) [152]	half-width (μm) [285], pg. 292	F(λ) (W cm^{-2} μm^{-1})	F(λ) (W m^{-2} Hz^{-1})
U	0.36	0.04	$4.35\ 10^{-12}$	$1.88\ 10^{-23}$
B	0.44	0.10	$7.20\ 10^{-12}$	$4.44\ 10^{-23}$
V	0.55	0.08	$3.92\ 10^{-12}$	$3.81\ 10^{-23}$
R	0.70	0.21	$1.76\ 10^{-12}$	$3.01\ 10^{-23}$
I	0.90	0.22	$8.3\ 10^{-13}$	$2.43\ 10^{-23}$
J	1.25	0.3	$3.4\ 10^{-13}$	$1.77\ 10^{-23}$
H (##)	1.62	0.2	$1.26\ 10^{-13}$	
K	2.2	0.6	$3.9\ 10^{-14}$	$6.3\ 10^{-24}$
L	3.4	0.9	$8.1\ 10^{-15}$	$3.1\ 10^{-24}$
M	5.0	1.1	$2.2\ 10^{-15}$	$1.8\ 10^{-24}$
N	10.2	6.0	$1.23\ 10^{-16}$	$4.3\ 10^{-25}$

(#) Fluxes for a 0.0 mag star.

Magnitude: izbruh supernove v M51

Table 1. Johnson-Cousins magnitudes of comparison stars

star	U	B	V	R	I
A	14.14*	14.05	13.44	13.08	12.81
A	···	14.005* ± 0.004	13.420* ± 0.002	13.067* ± 0.003	12.730* ± 0.00
B	···	16.57:	15.09:	14.39:	13.65:
B	···	16.339 ± 0.017	15.096 ± 0.007	14.331 ± 0.009	13.680 ± 0.005
C	···	15.751 ± 0.017	15.212 ± 0.010	14.857 ± 0.013	14.497 ± 0.010
D	···	16.168 ± 0.016	15.266 ± 0.007	14.746 ± 0.009	14.200 ± 0.005

*Adopted as primary comparison star values.

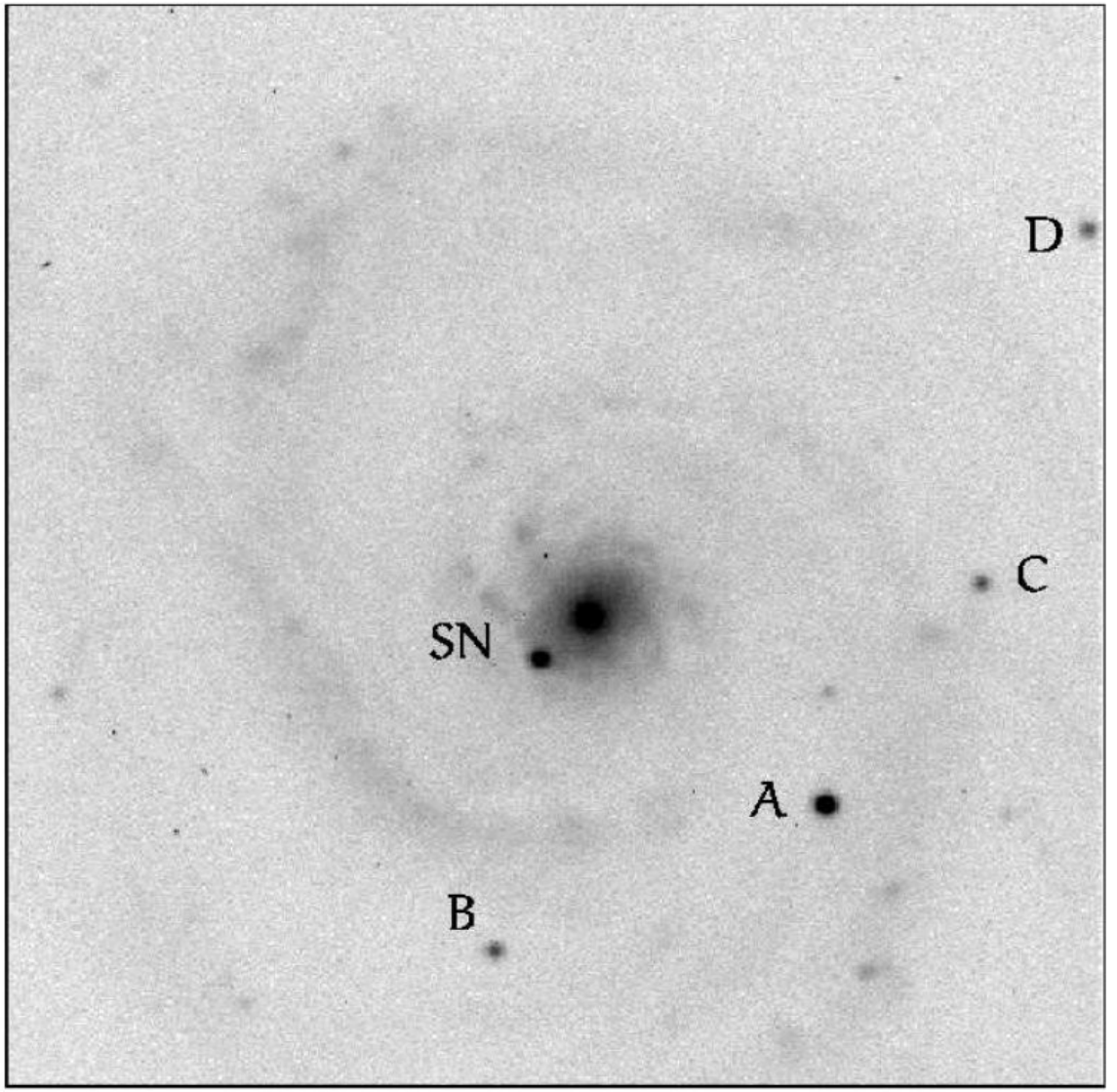


Fig. 1.— V-band image of M51 (= NGC 5194) and SN 1994I taken Apr 2, 1994, with comparison stars marked. North is up and East to the left. The field of view is about 5′.3 × 5′.3. SN 1994I is about 19″ from the nucleus of M51.

Magnitude: izbruh supernove v M51

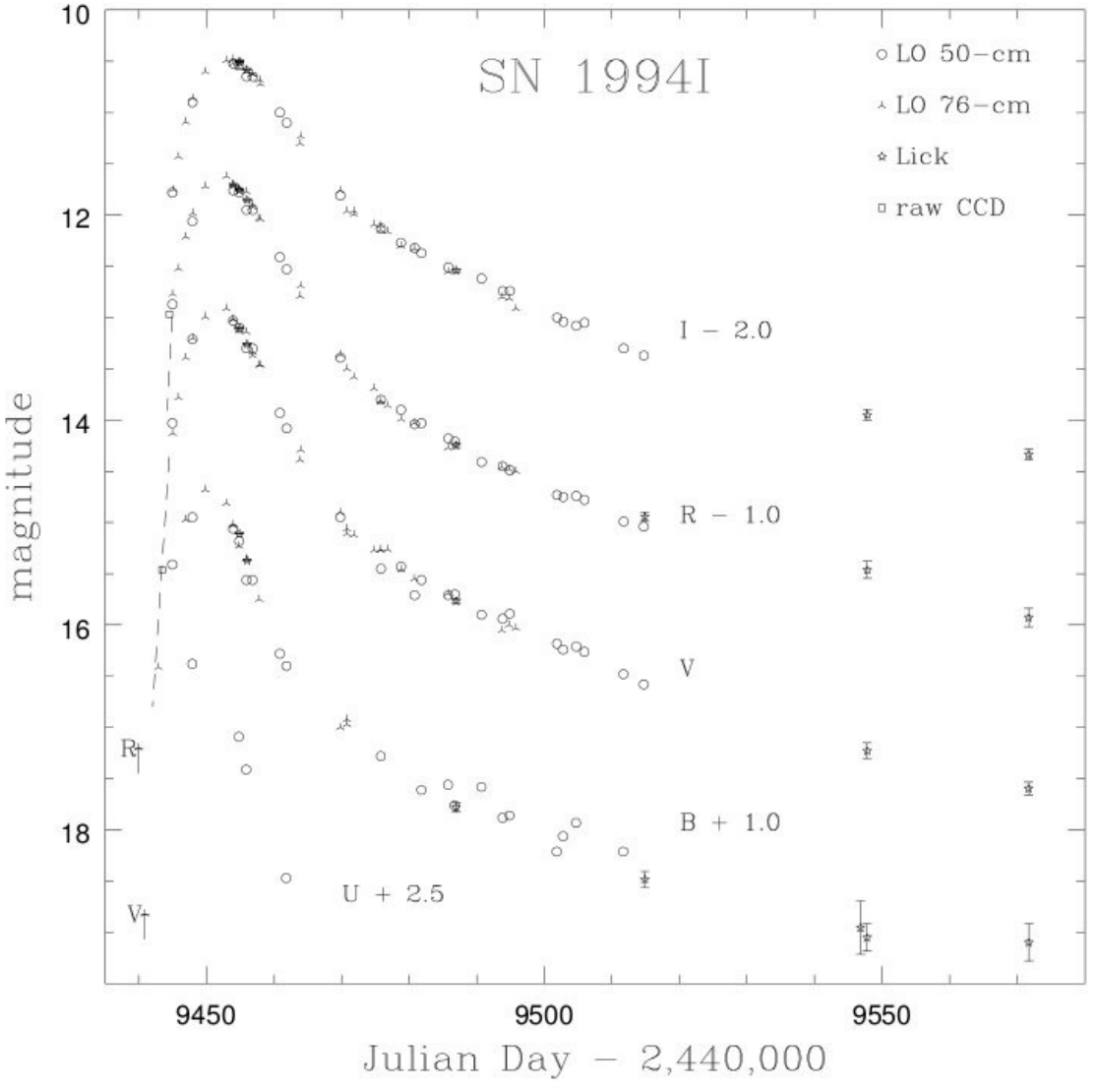
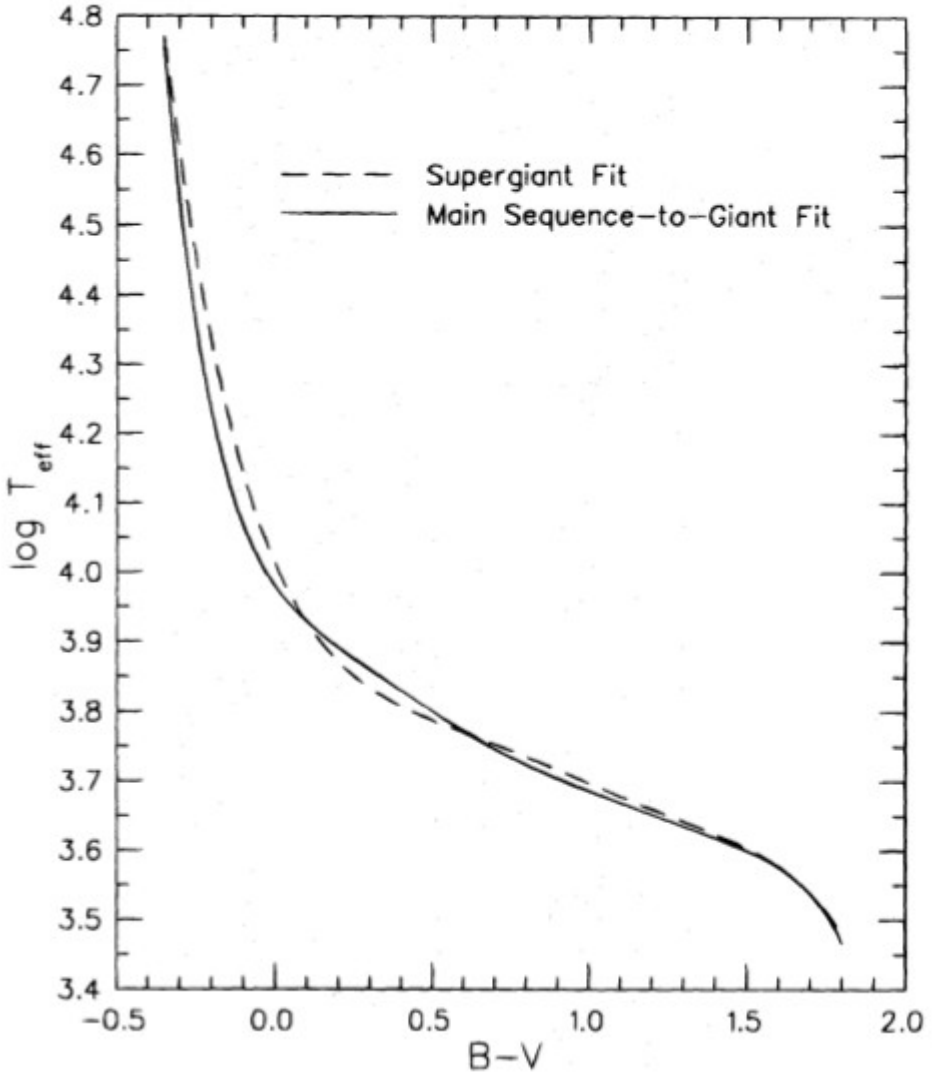
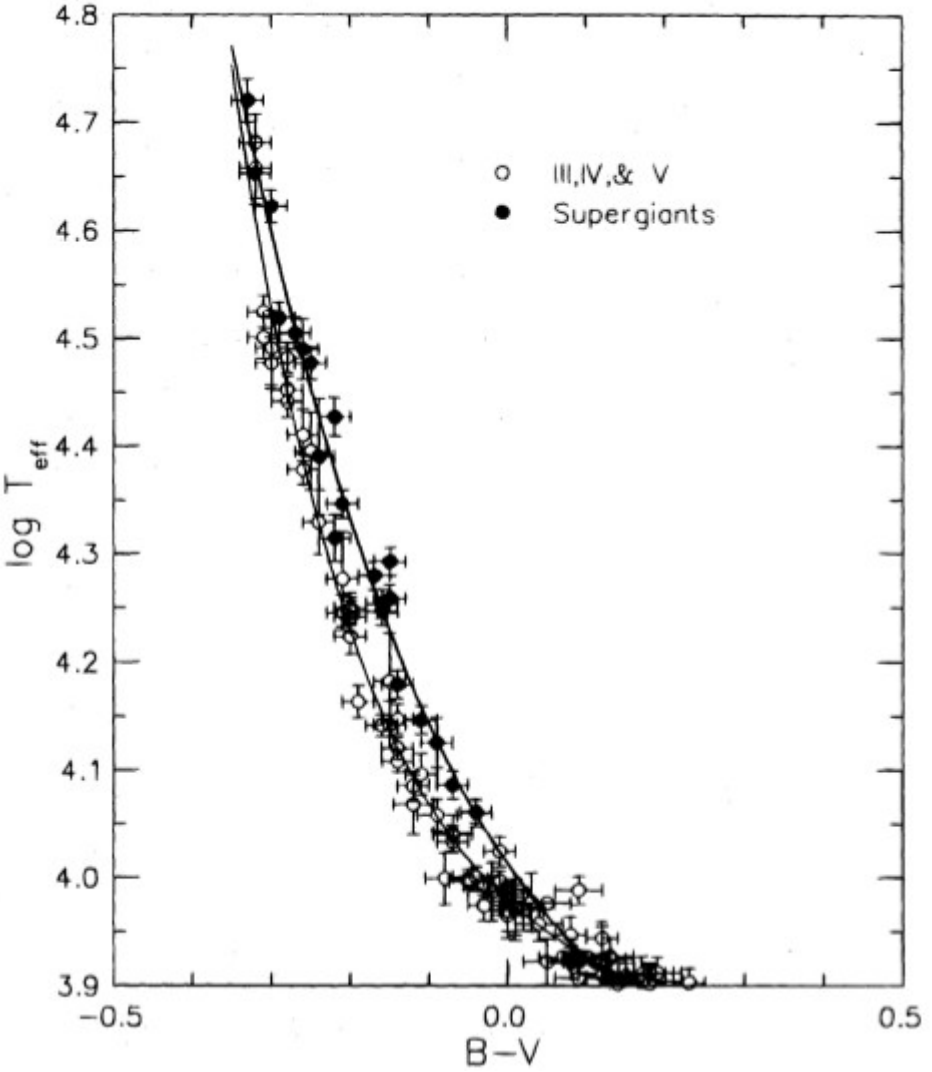


Fig. 3.— *UBVRI* light curves of SN 1994I.

Barve zvezd – ozvezdje Orion

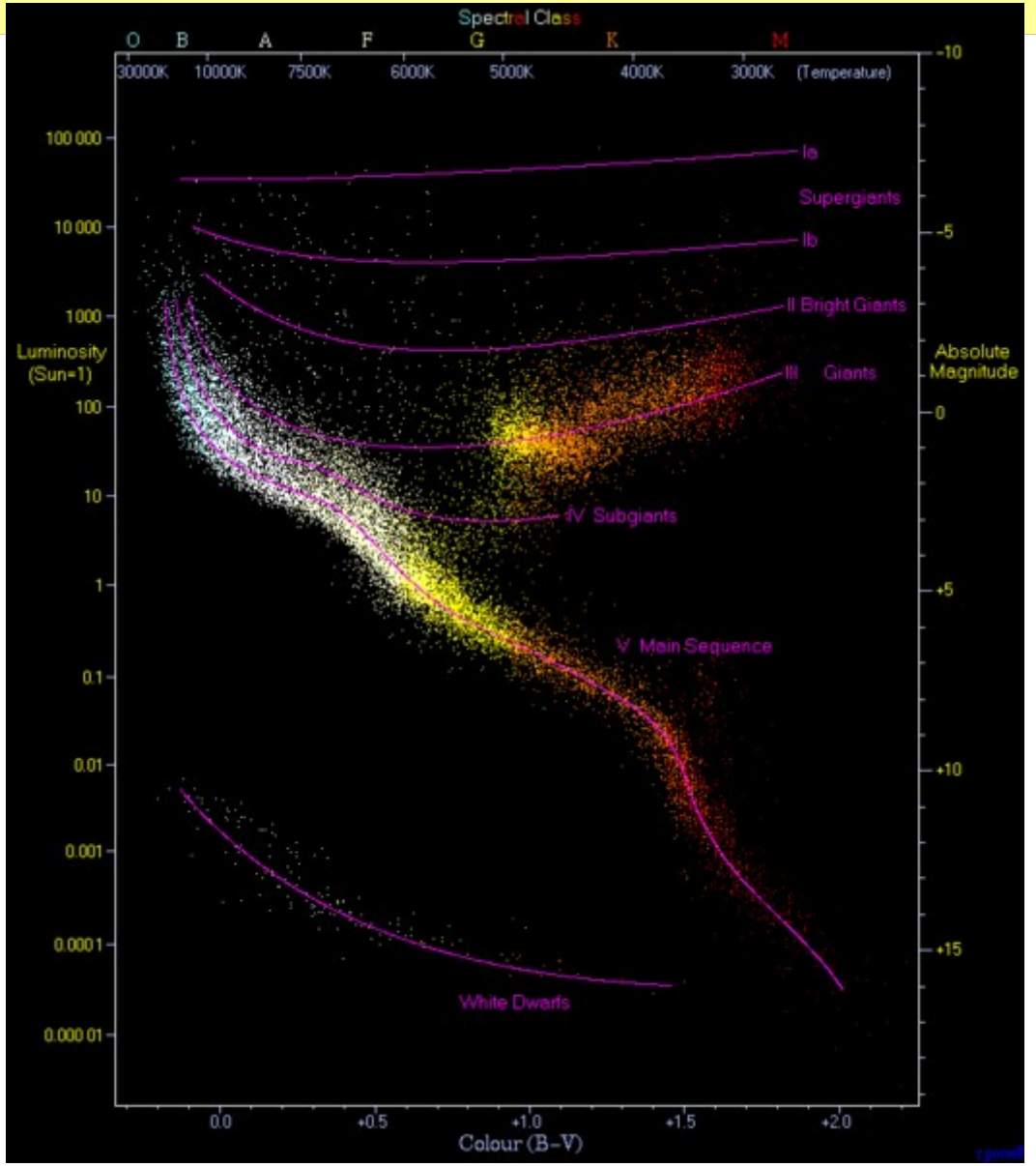
Barve in temperature zvezd



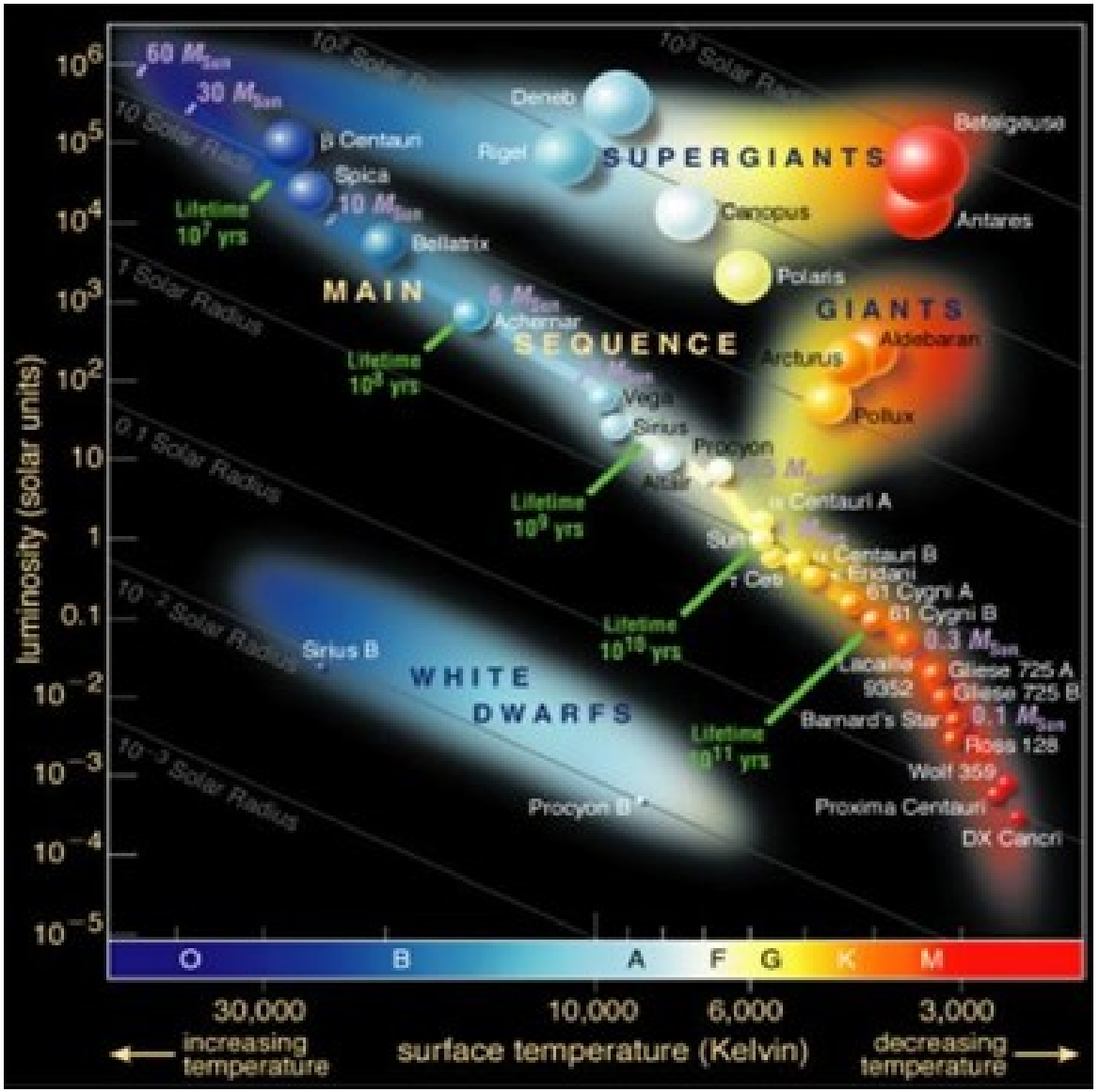


Sonce: T_{eff} = 5780 K, log T_{eff} = 3,762, B-V = 0.656 +- 0.005.

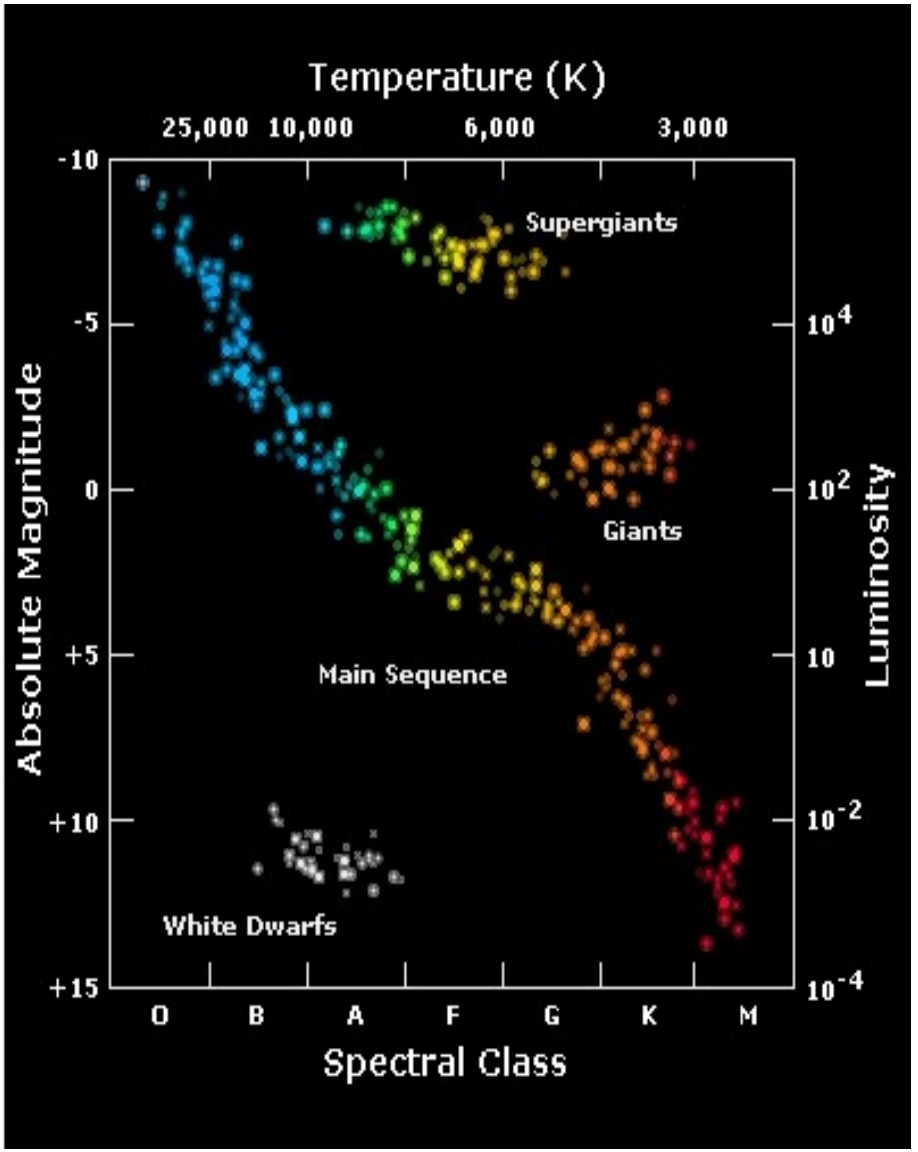
Barve in temperature zvezd



Hertzsprung – Russelov (HR) diagram



Hertzsprung – Russelov (HR) diagram



Zvezdne kopice*

• Enotne populacije zvezd: zvezde so bile rojene (skoraj) hkrati in iz istega oblaka, torej imajo isto starost in kemično sestavo

Odprte (razsute) kopice:
- vsebujejo 10-1000 zvezd
- nepravilnih oblik

Kroglaste kopice:
- tisoč - milijon zvezd
- kroglasta osrednja zgostitev

* ta in naslednjih 21 prosojnic je povzetih po predavanju o zvezdnih populacijah dr. Michaela L. Balogha z Univerze v Waterlooju, Ontario, Kanada (http://quixote.uwaterloo.ca/~mbalogh/)

Galaksije

- **vsebujejo milijarde zvezd**
- **zvezde so različne starosti in kemične sestave**

Zvezdni sistemi

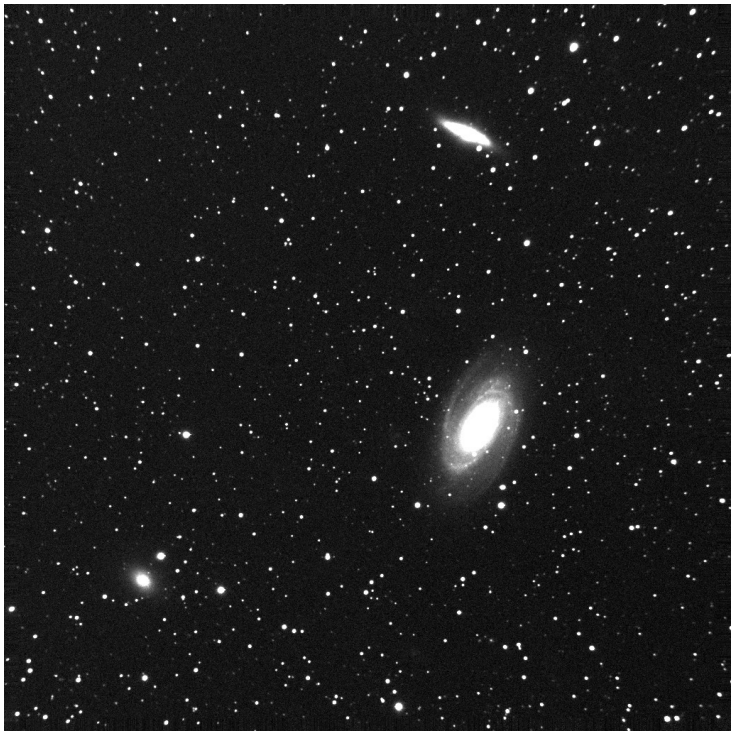
Jate galaksij:

- nekaj deset galaksij, ki krožijo ena okoli druge (so gravitacijsko vezane)

Superjate galaksij:

- Tisoči galaksij, bilijoni zvezd
- Največje vezane strukture v Vesolju

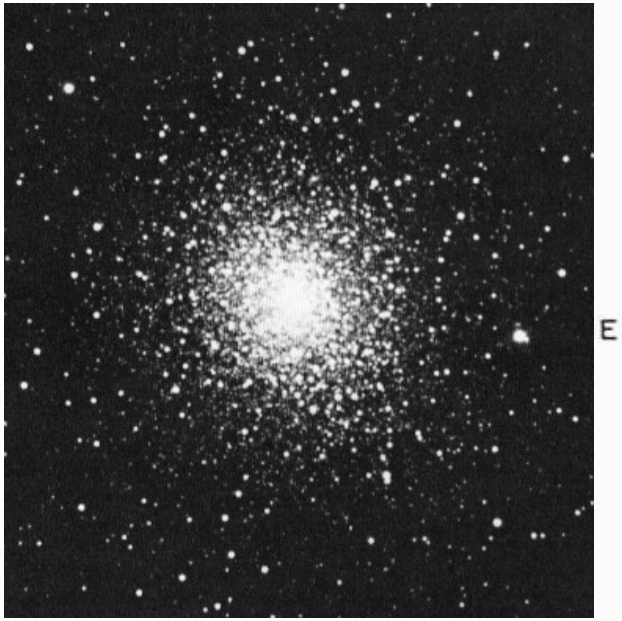
~5×10^5 pc

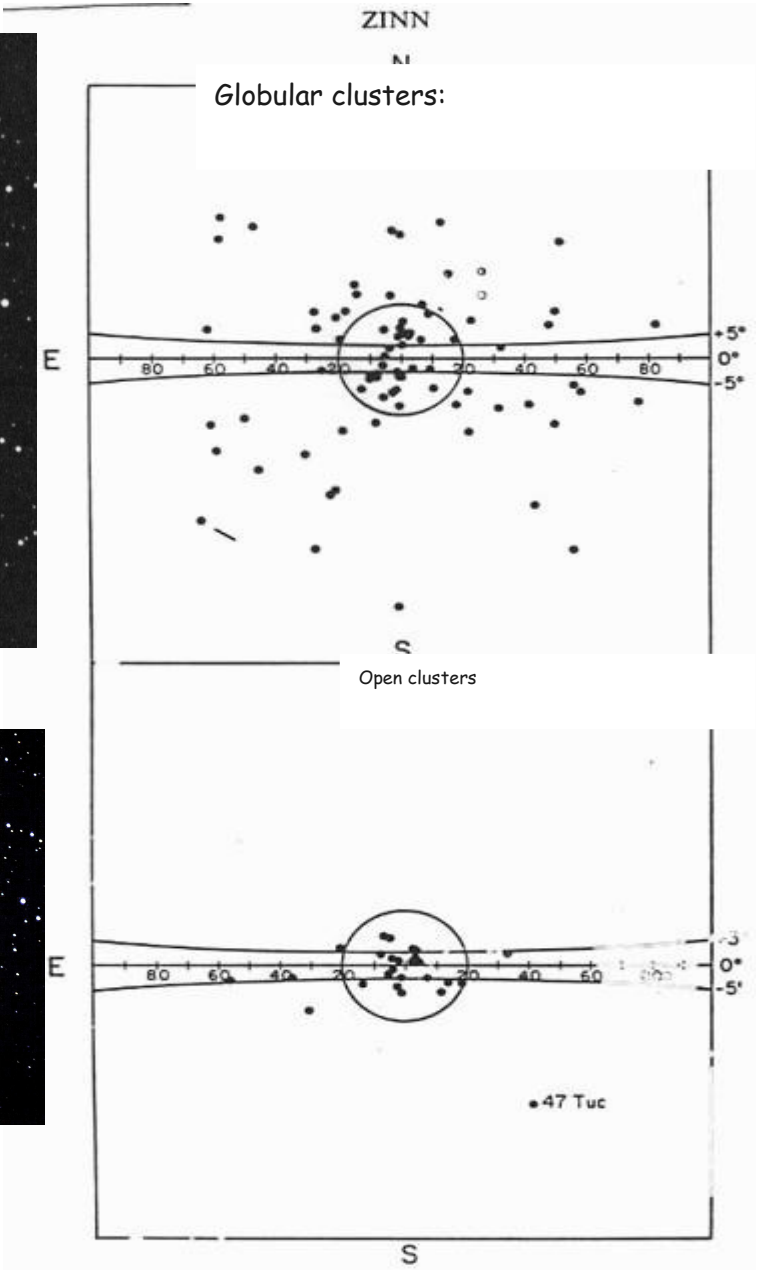


~2×10^6 pc

Kroglaste kopice

- Mostly found in the halo of the Milky Way
  - Concentrated around the Galactic centre
  - In fact their spatial distribution was first used to identify the centre of the Galaxy

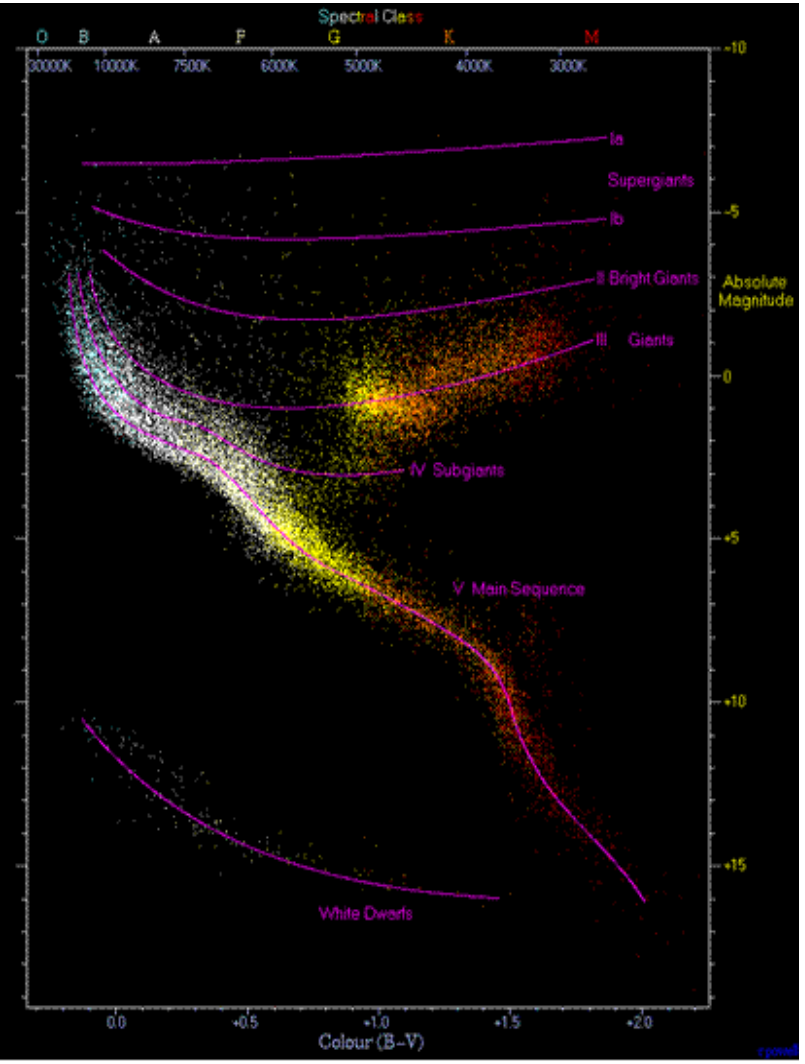


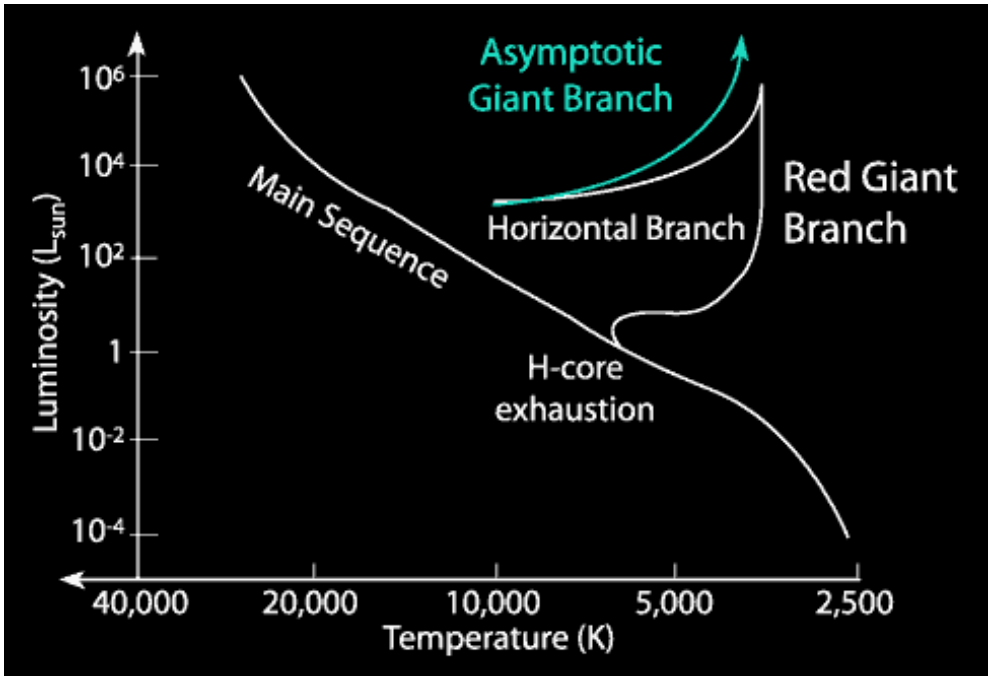


Odprte kopice

- Večinoma jih najdemo v disku Galaksije

Pregled: razvoj zvezd

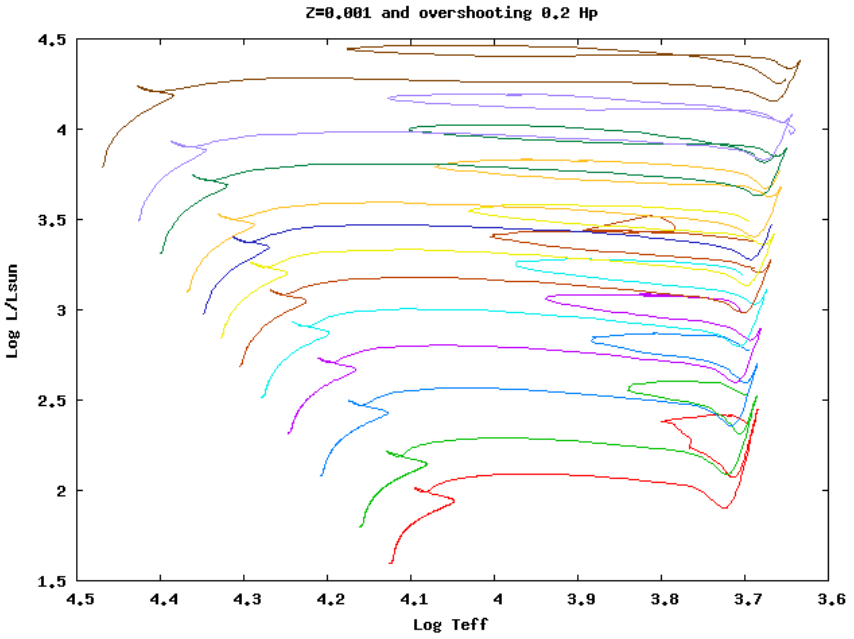




Glavna veja: v jedru se spaja vodik
Veja rdečih orjakinj: spajanje vodika v lupini
Vodoravna veja: v jedru se spaja helij
Asimptotska veja rdečih orjakinj: spajanje helija (in vodika) v lupinah, okrog jedra iz ogljika in kisika, ki ga podpira tlak degeneriranih elektronov

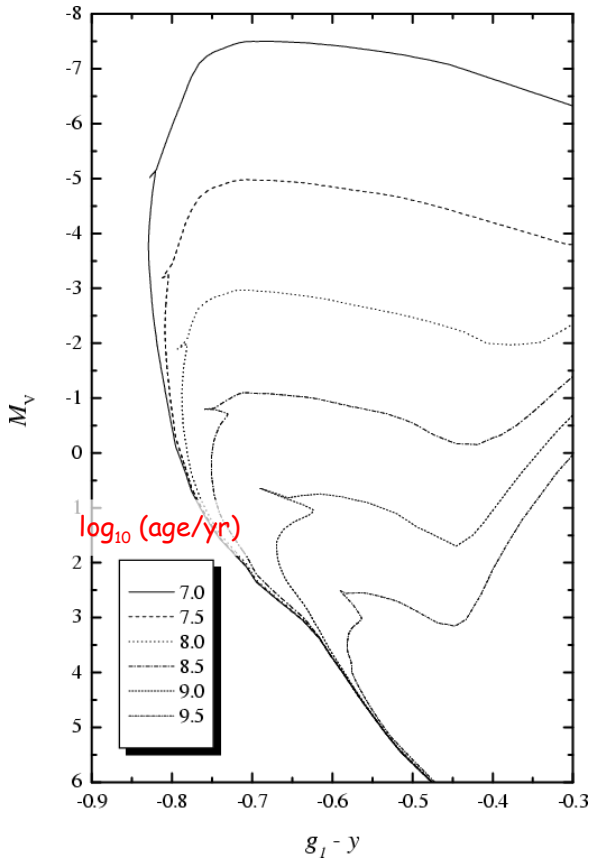
Izohrone in razvojne sledi

- Za dano maso lahko gledamo,
- kako se položaj razvija s časom



Modeli za različne mase

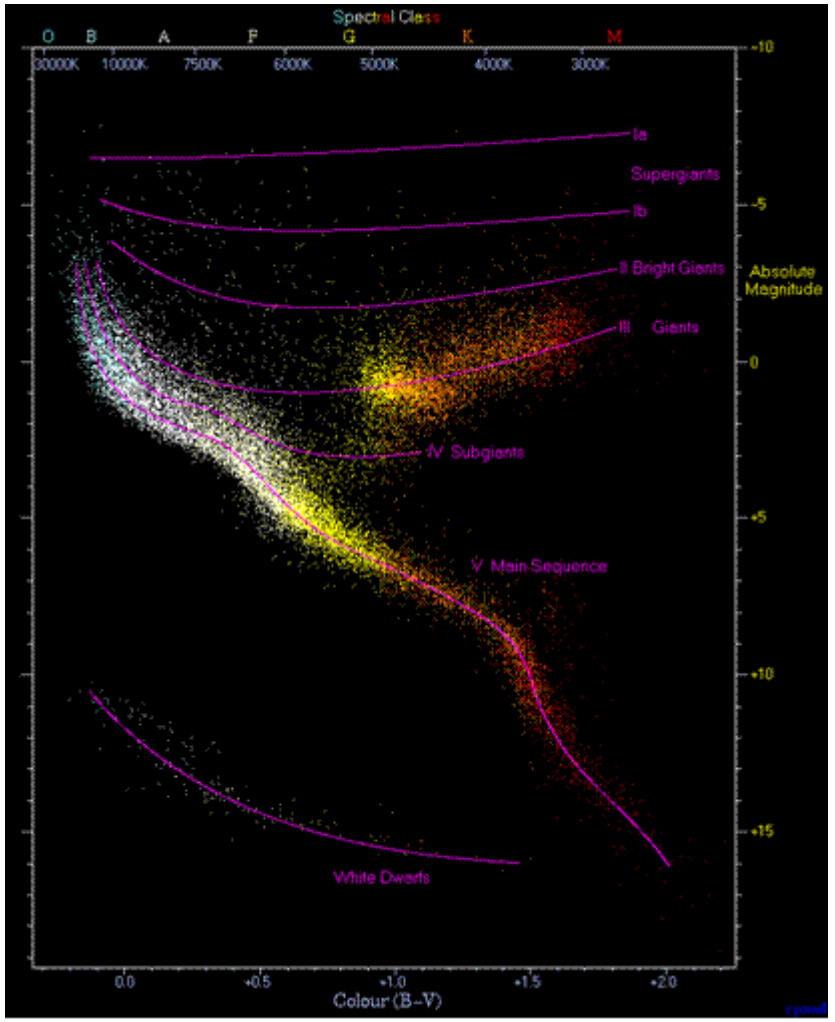
- Za skupino zvezd s porazdelitvijo mas lahko narišemo, kje bodo ob določenem času: tem črtam pravimo *izohrone.*



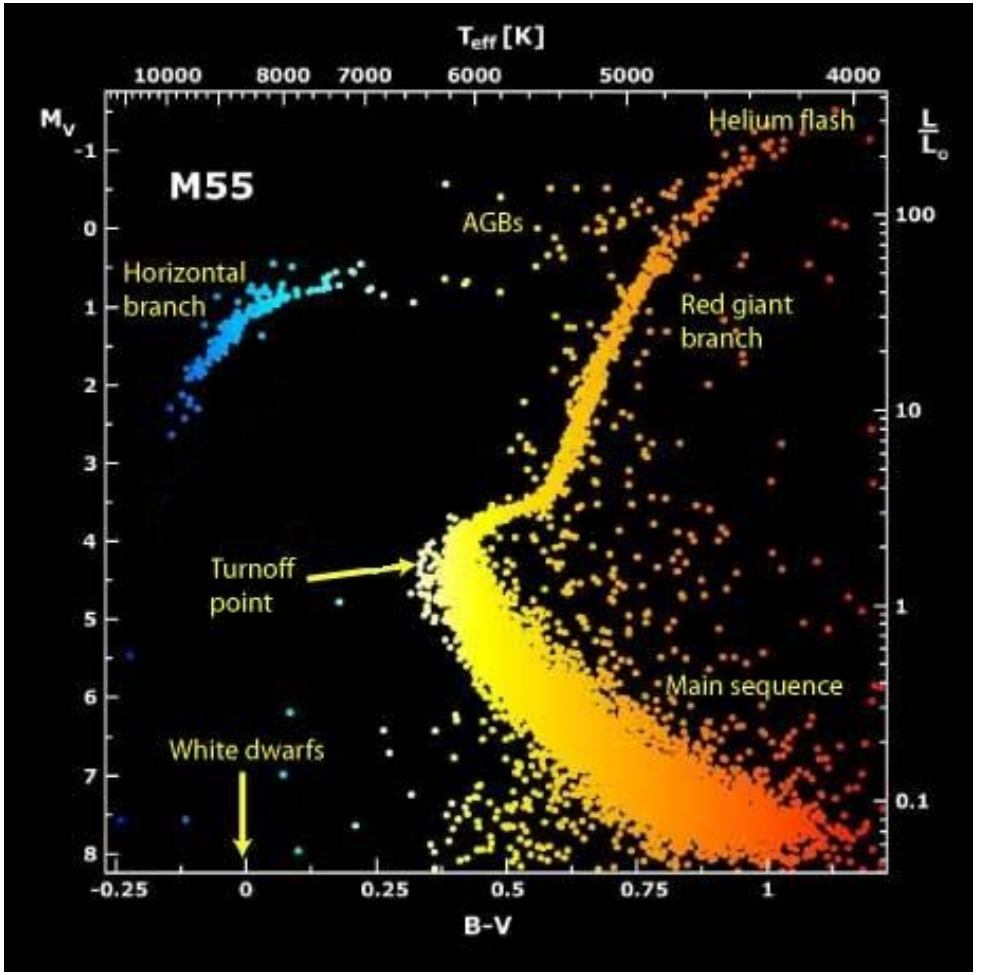
Modeli za različne starosti

Populacije ene starosti

Bližnje zvezde vseh starosti



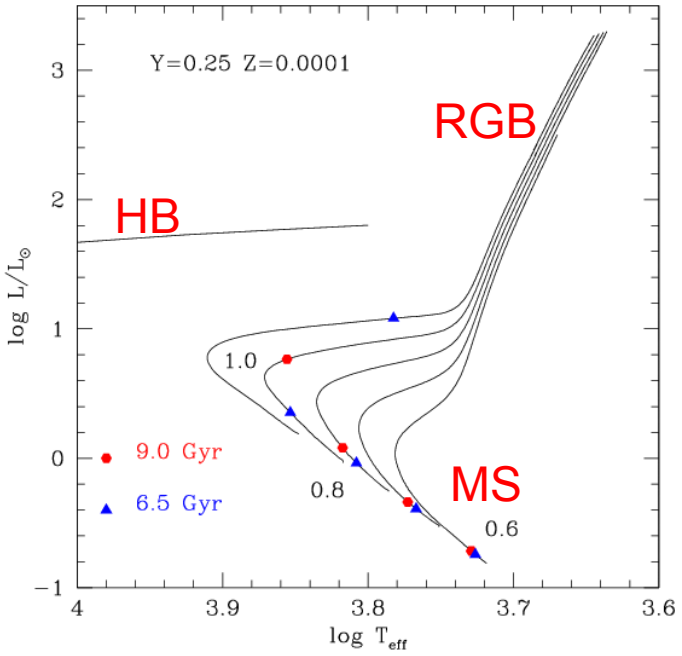
Kopica zvezd, ki so vse nastale hkrati

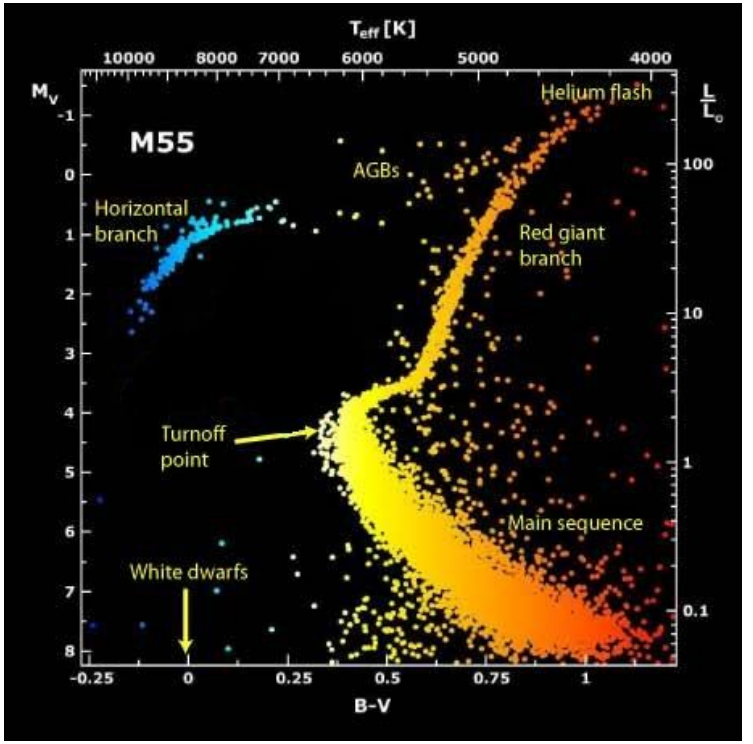


Zvezdne kopice

- Barvno magnitudni diagram kopice vsebuje informacije o starosti in kemični sestavi kopice.

Razvojne poti zvezd različnih mas

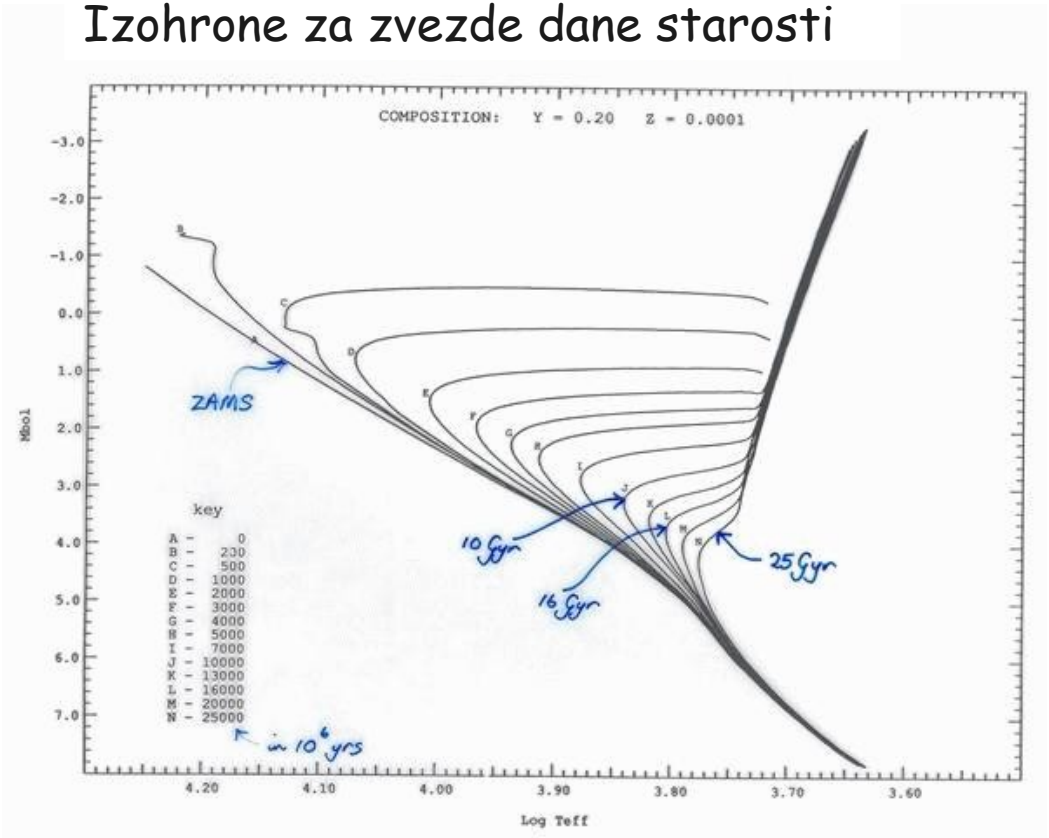


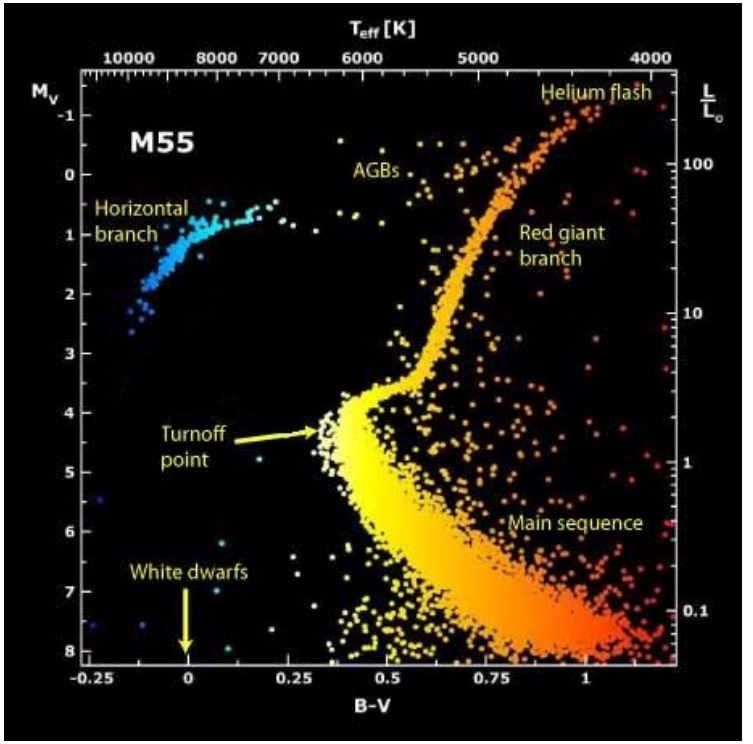


Zvezdne kopice

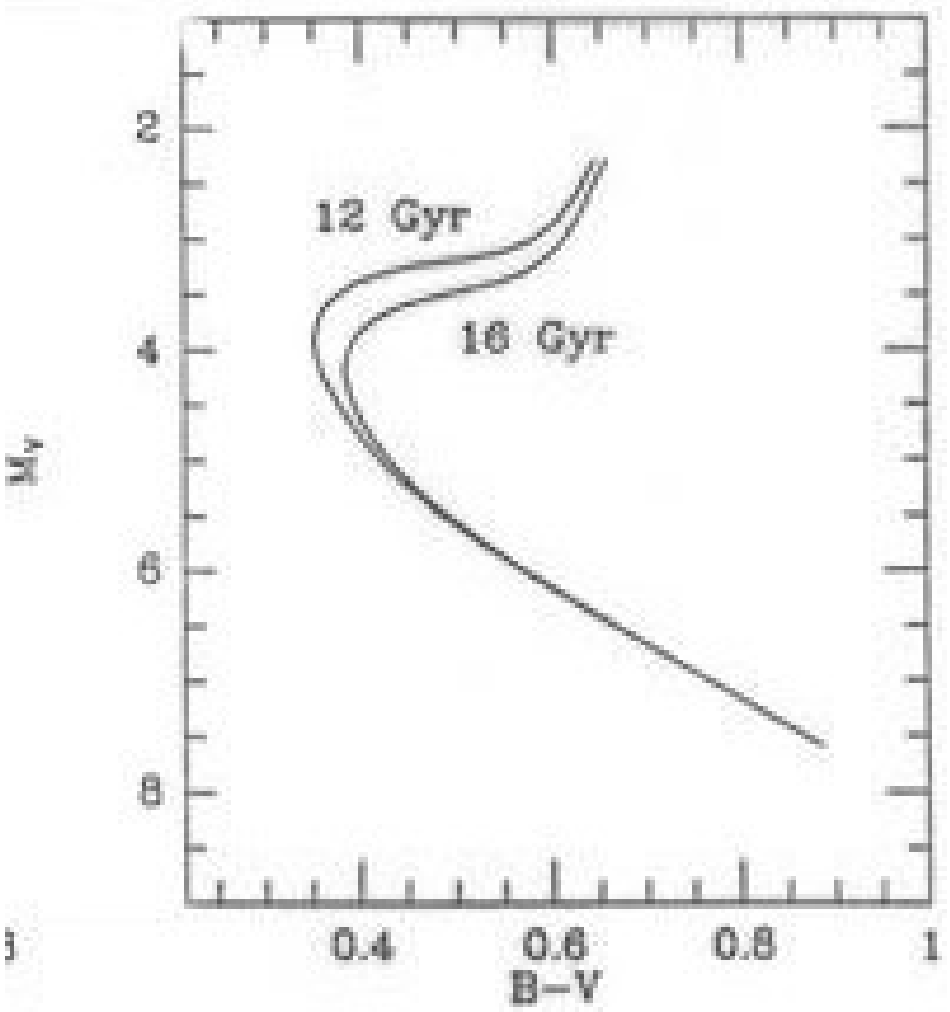
- Barvno magnitudni diagram kopice vsebuje informacije o starosti in kemični sestavi kopice.

Izohrone za zvezde dane starosti





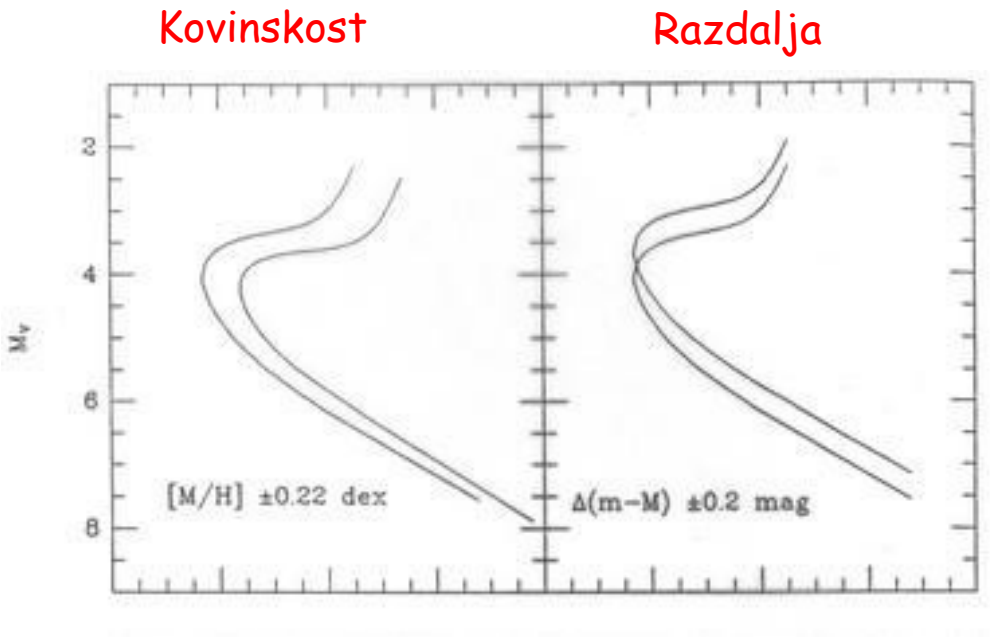
Teoretične izohrone



- Koleno glavne veje (MSTO) je dober indikator starosti kopice.

Teoretične izohrone

- Zvezde z več težkimi elementi (kovinsko bogate) so nekoliko bolj rdeče.



- Magnituda kolena glavne veje je odvisna od razdalje.
- Barva je odvisna od kovinskosti.

Teoretične izohrone

- Zvezde z več težkimi elementi (kovinsko bogate) so nekoliko bolj rdeče.

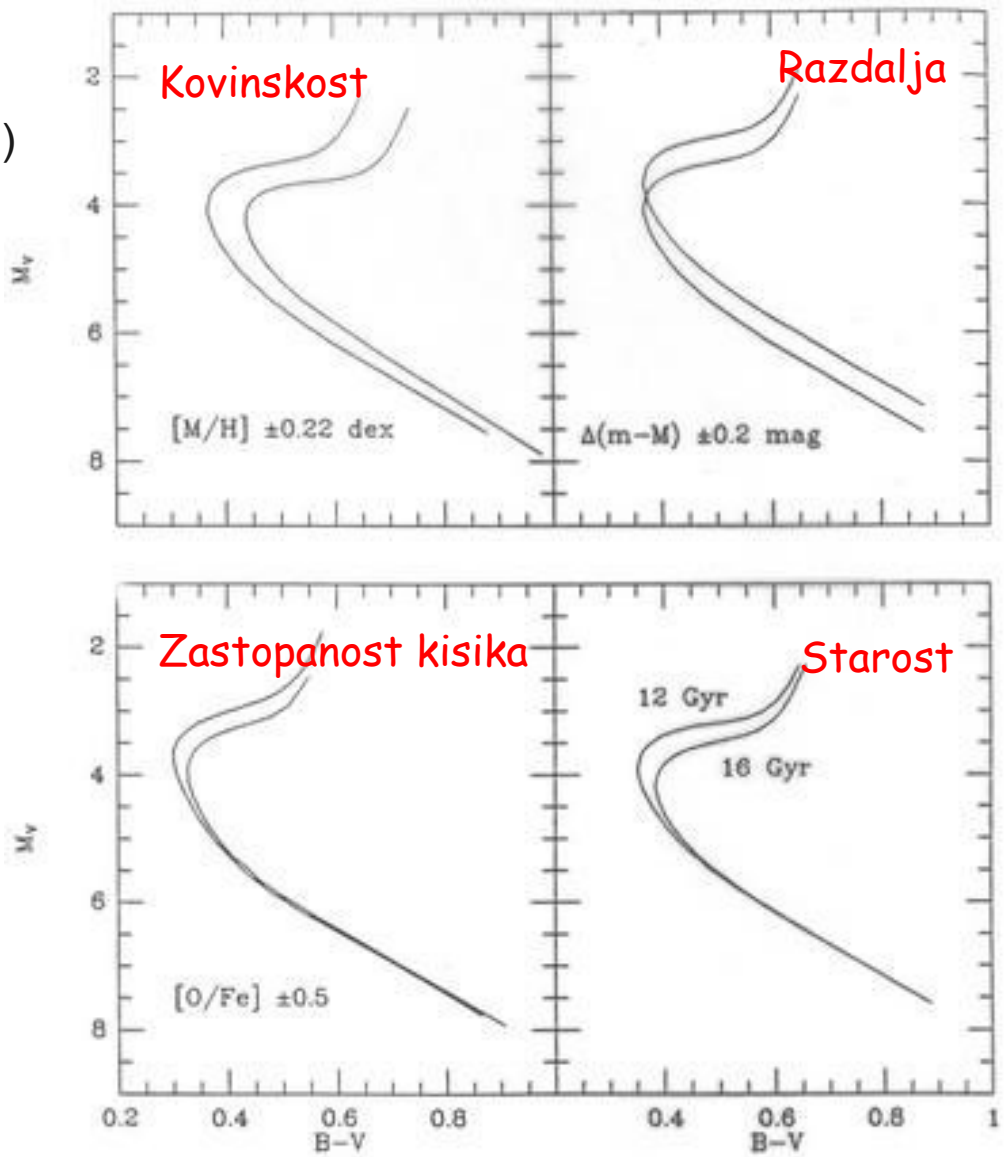


FIG. 1—The four panels show the effects of varying the labelled parameters with all other parameters held constant. The amount of the variation of any one parameter is chosen to be the ±1σ values typical for a well observed cluster.

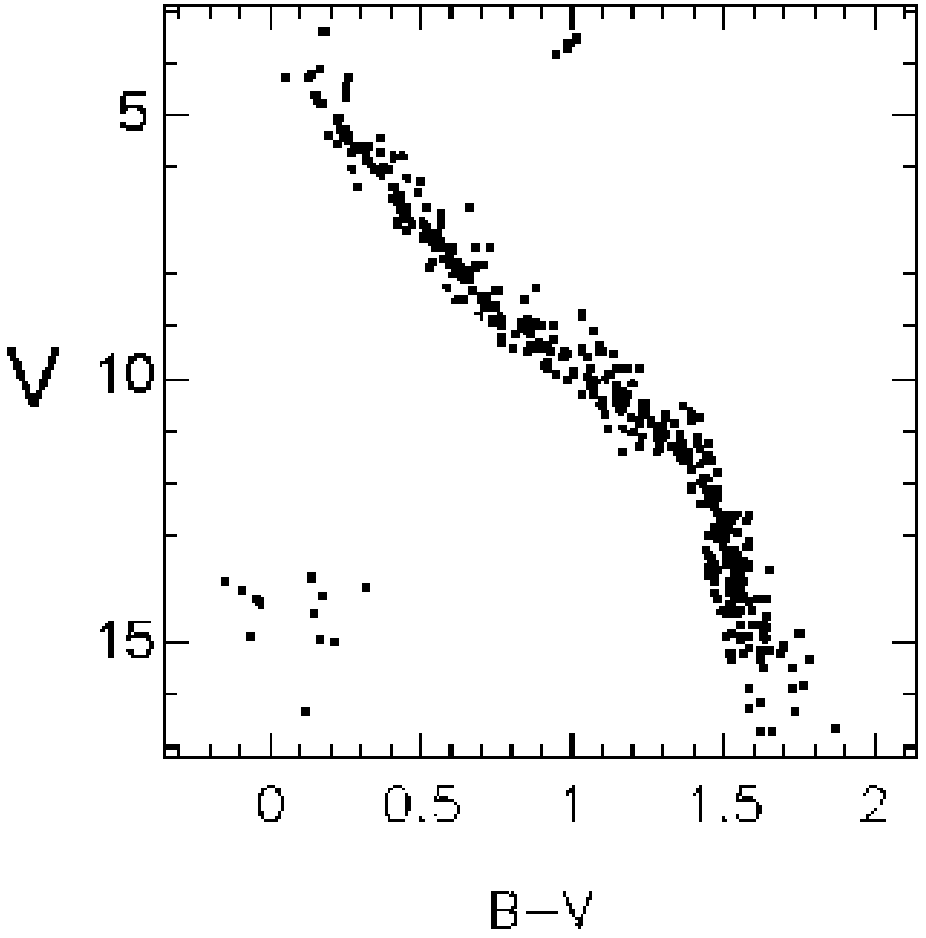
- Magnituda kolena glavne veje je odvisna od razdalje.
- Barva je odvisna od kovinskosti.

- Koleno glavne veje je dober indikator starosti kopice.

Barvno-magnitudni diagrami

Mlada kopica:

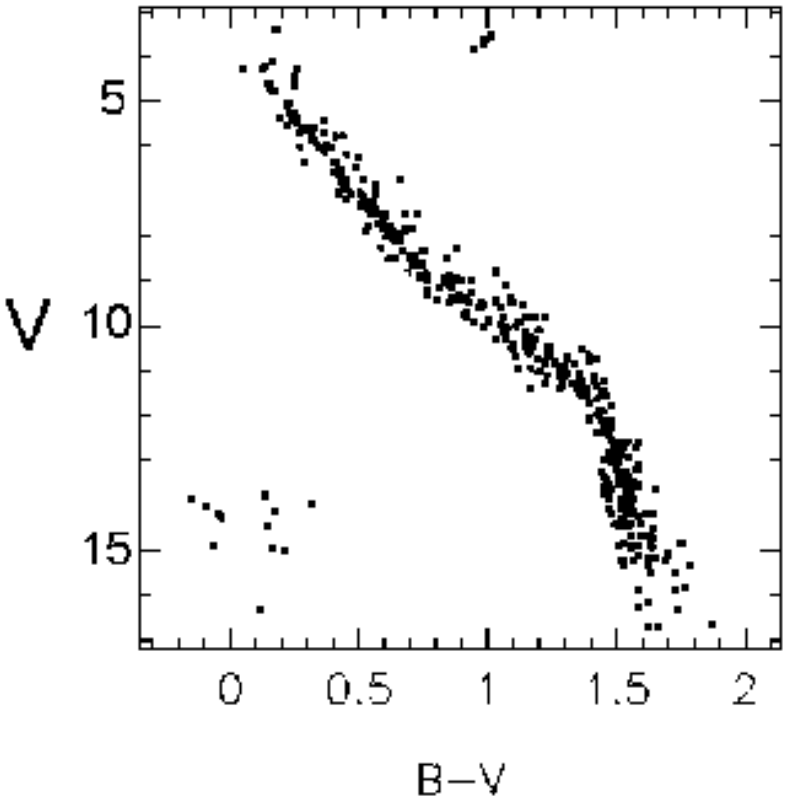
- Najbolj vpadljiva struktura je glavna veja.
- Ni bilo še dovolj časa, da bi zvezde zapustile glavno vejo.



Odprte (razsute) kopice

Primer: Hiade

Spekralni tip	B-V	Starost, ko zapustijo glavno vejo (10^9 let)
O	-0.4	<0.001
B	-0.2	0.03
A	0.2	0.4
F	0.5	4
G	0.7	10
K	1.0	60
M	1.6	>100



- Barva najsvetlejših zvezd glavne veje je (B-V)~0.1
- To ustreza spektralnemu tipu A0.

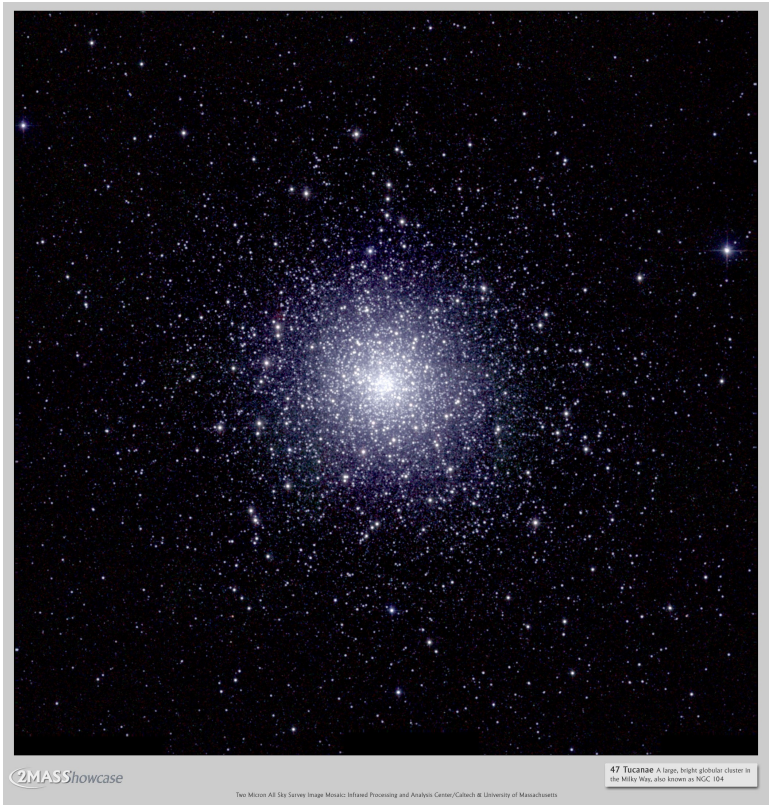
Odprte kopice

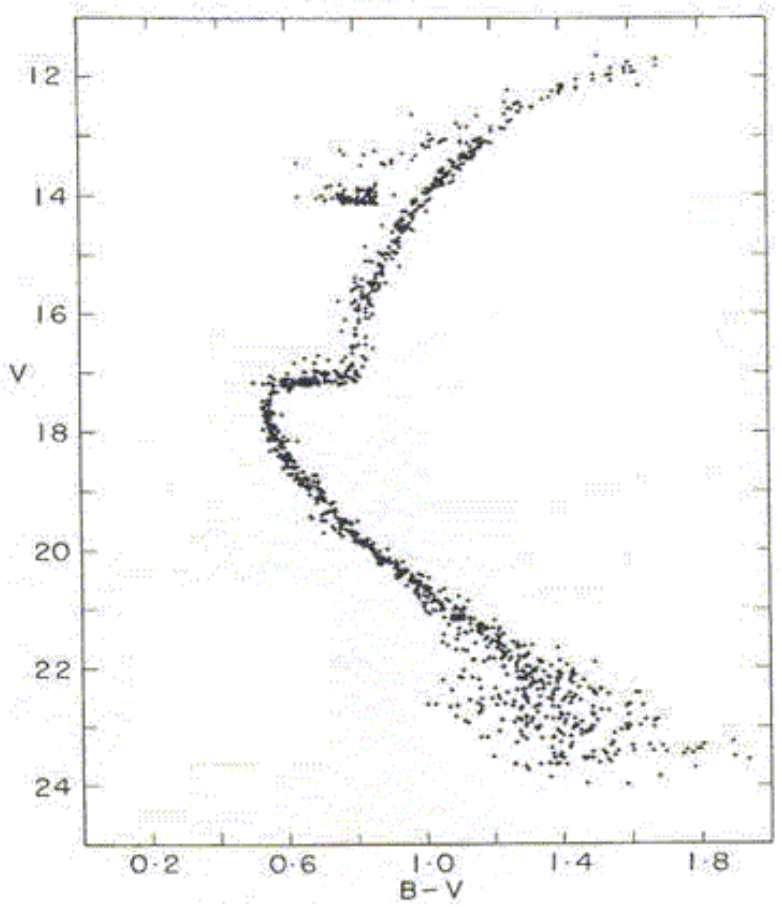
- navadno mlade in kovinsko bogate, starost <1 milijarda let
- večinoma v disku naše Galaksije

Ime	**Starost (Myr)**	**Razdalja (pc)**	**[Fe/H]**
Collinder 285	199	25	0
Melotte n25	787	45	+0.17
Melotte 111	449	96	0
Mamajek 1	7.9	97	0
Melotte 227	135	120	0
Platais 8	60.2	132	0
Melotte 22	135.2	150	0
IC 2602	32.1	161	-0.09
Platais 3	398	161	0
Platais 9	100	174	0

Kroglaste kopice

47 Tukana



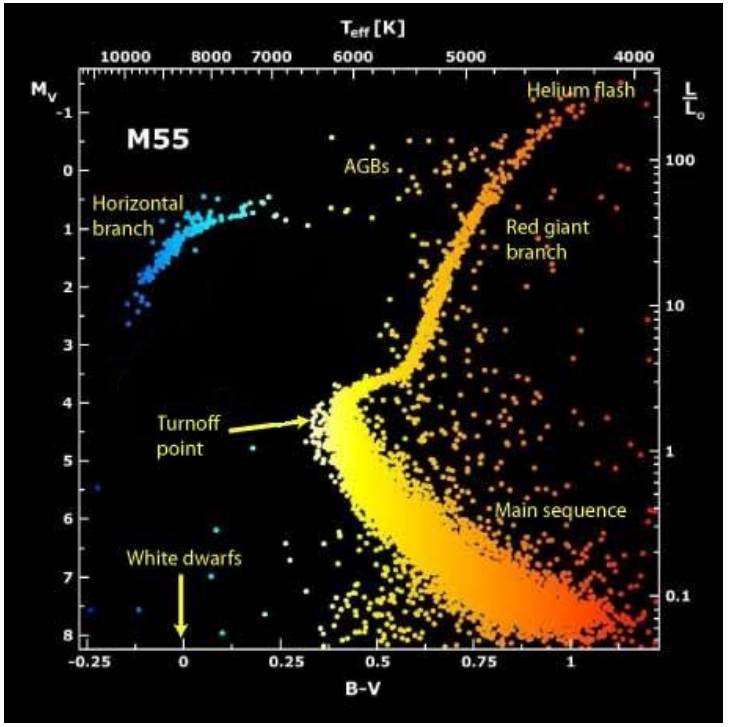


Stare kopice:

- Le najtemnejše zvezde (majhnih mas) so še na glavni veji.
- Večina zvezd v barvno-magnitudnem diagramu je v fazah razvoja po glavni veji.

NGC 2419

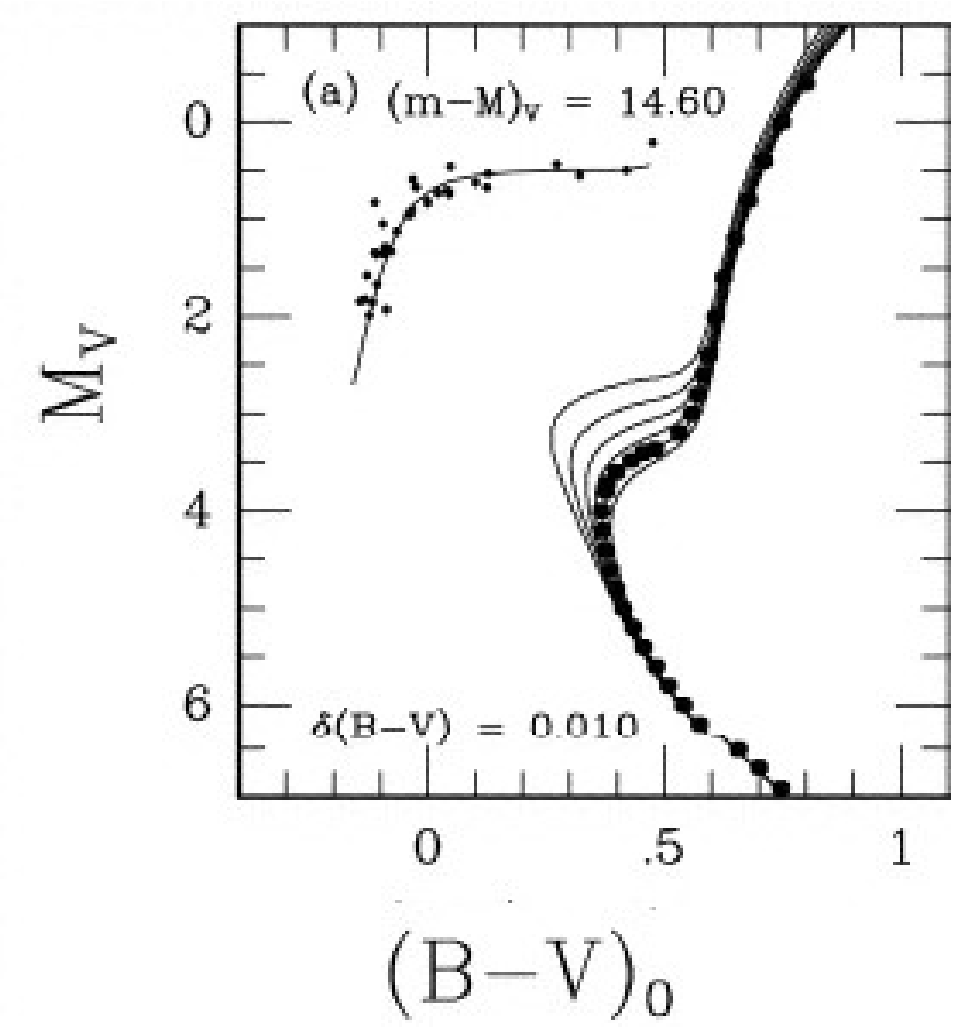
- V starih kopicah so svetle modre zvezde na horizontalni veji, medtem ko so rumeno rdeče zvezde orjakinje



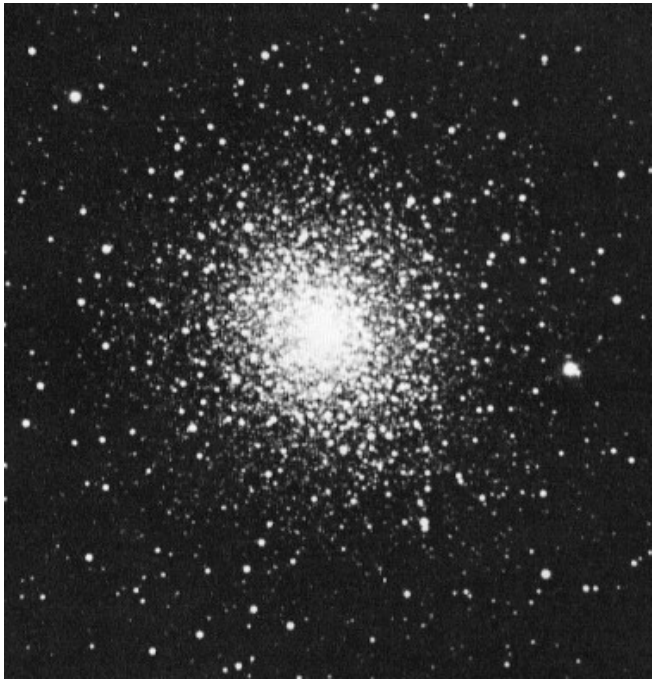
Kroglaste kopice

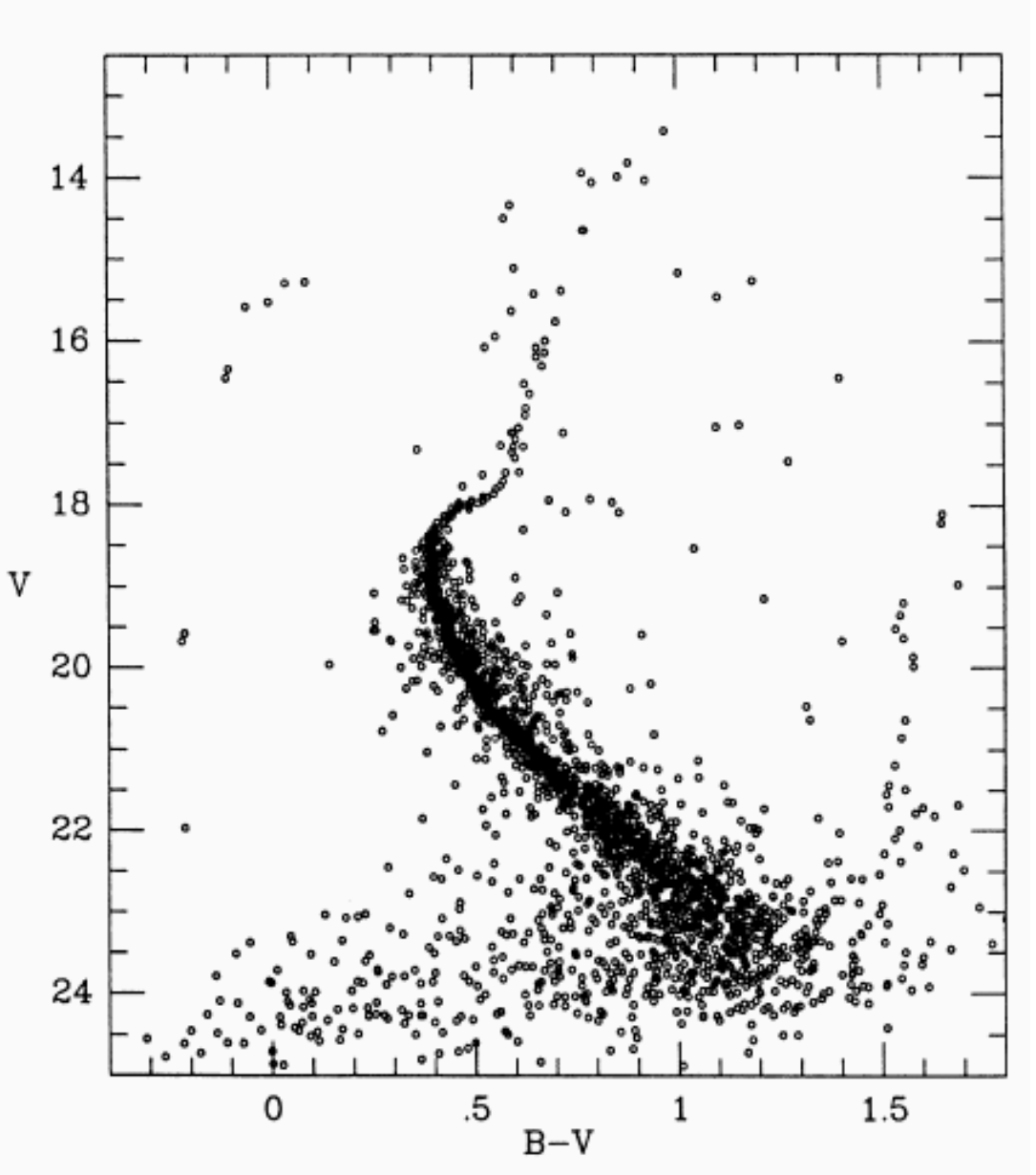
- Za dano kemično sestavo in razdaljo skušamo določiti modelsko starost, ki se najbolje ujema s podatki.

- Tu so narisane izohrone za starosti 8,10,12,14,16,18 Gyr.



Kroglaste kopice

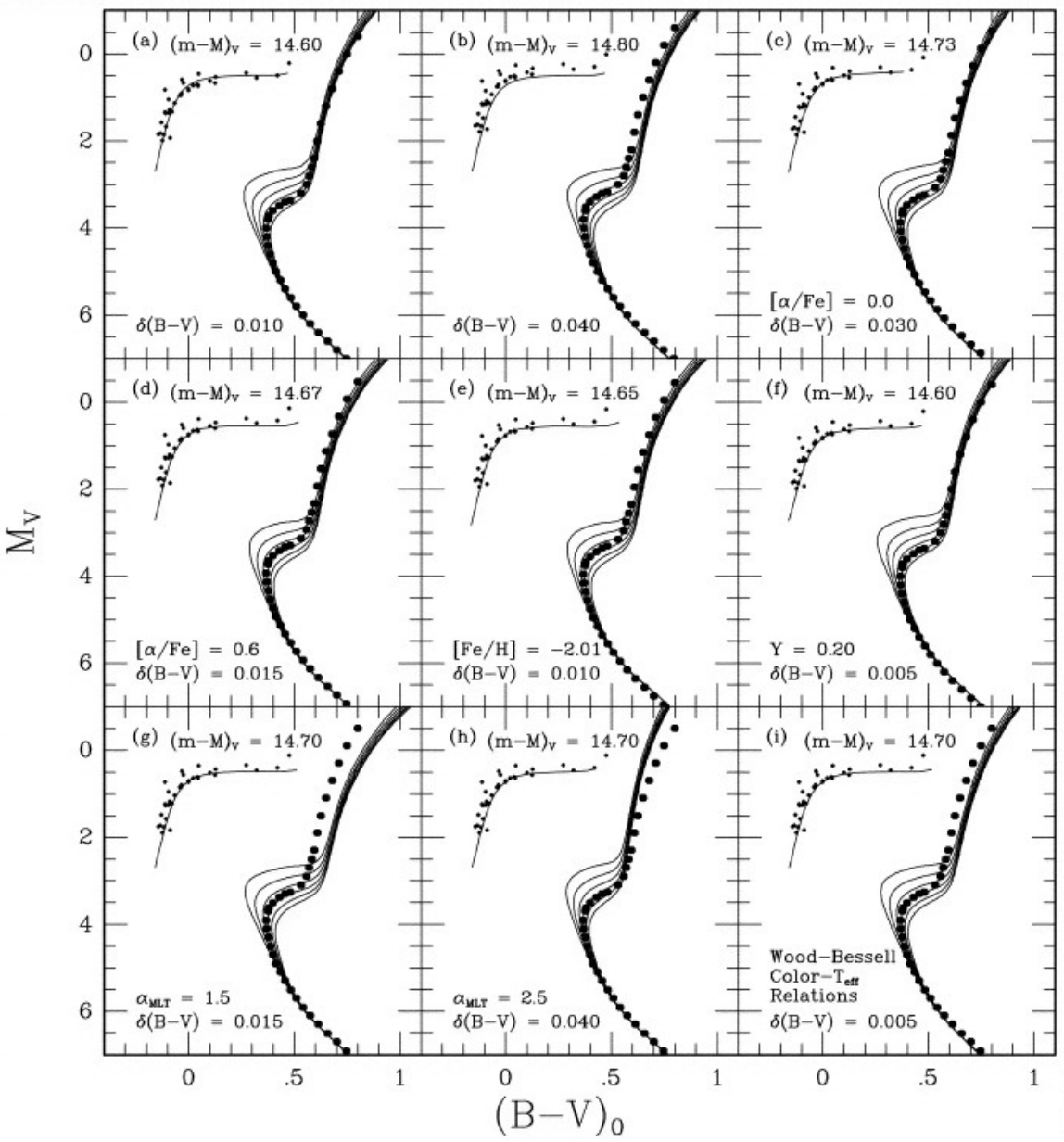




Primer: M92

- **Najboljše ujemanje:**
  - **starost=14.2 ± 1.2 Gyr**.
  - [Fe/H]=-2.31

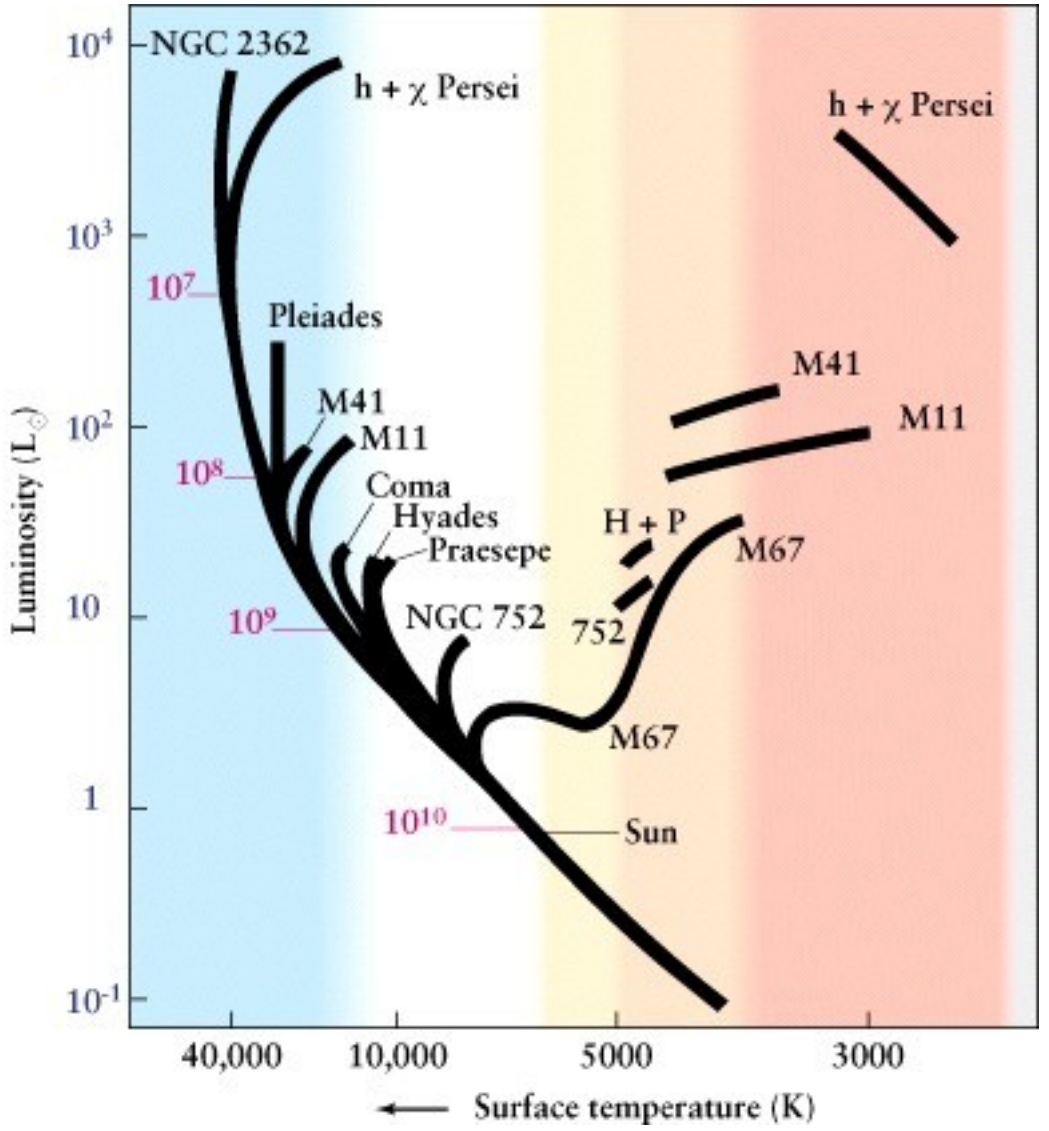
Kroglaste kopice



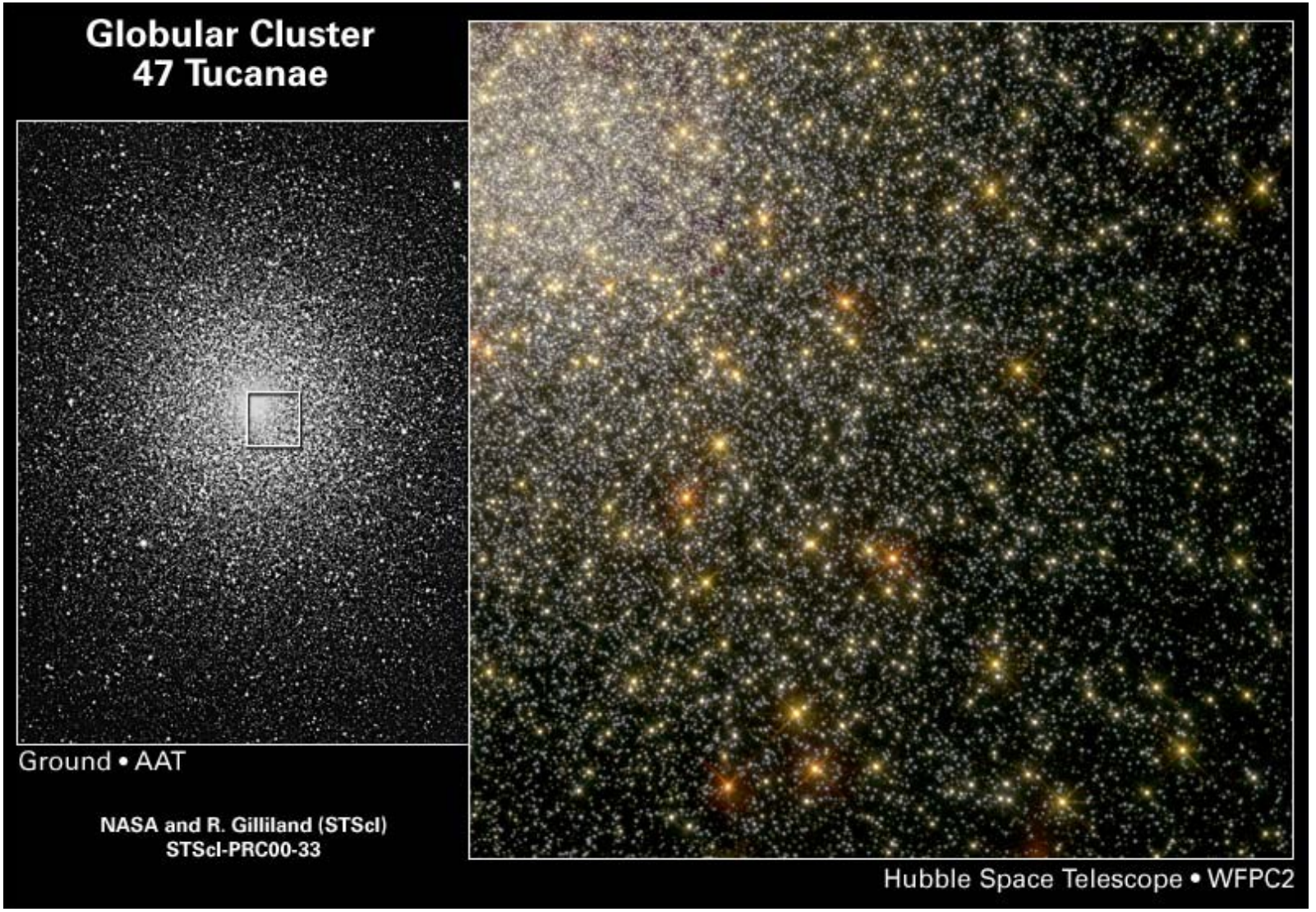
- Izohrone za 8,10,12,14,16,18 Gyr. Posamezni grafi so za različne kemične sestave in razdalje.

Starost kopic

- Prilagajanja izohron za različne odprte in kroglaste kopice.
- Vidimo različne starosti in morfologije HR-diagramov, ki jih kažejo ti objekti.

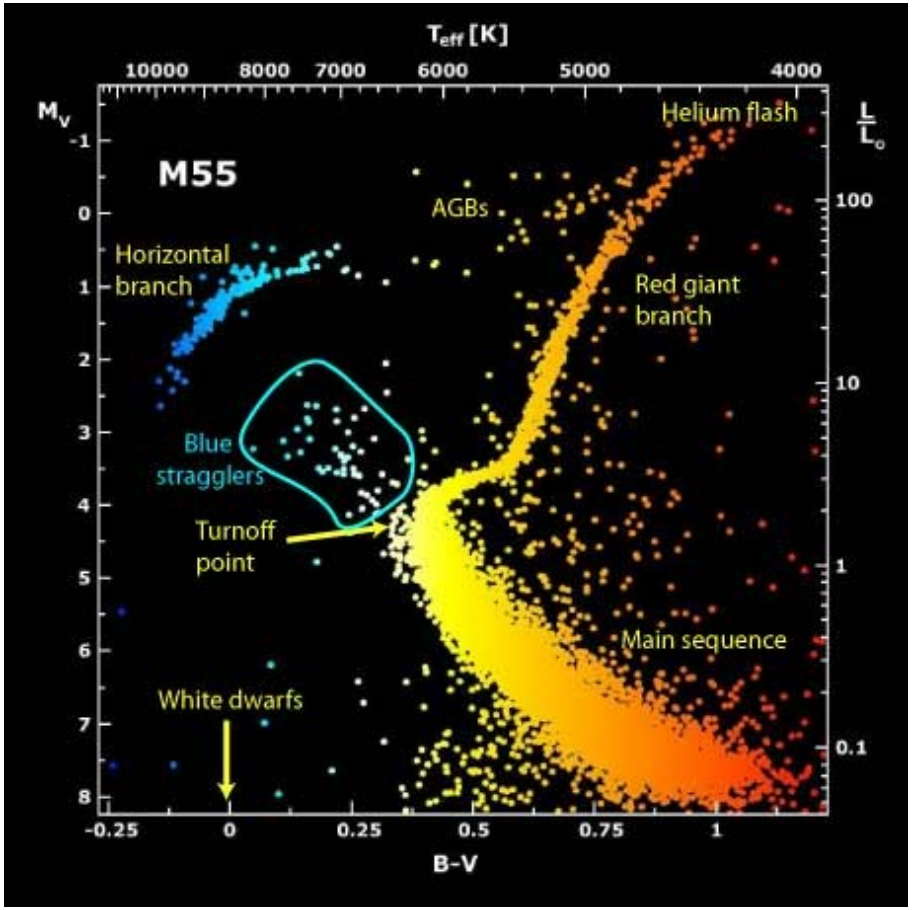


Opazovalne težave

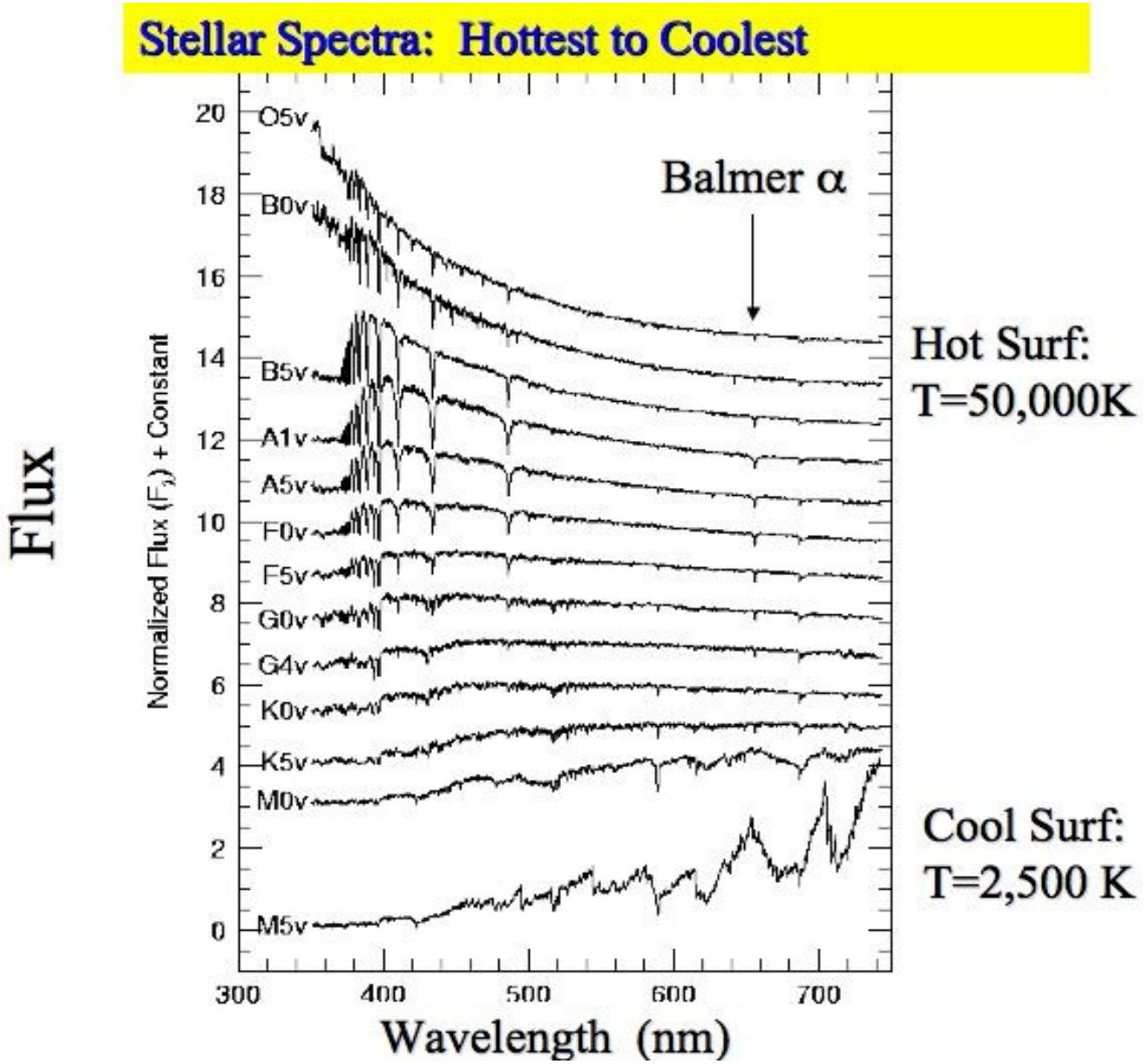


Opazovalne težave

- Neničelna širina kolena glavne veje
- Obstoj modrih obotavljivk, ki so verjetno dvojne zvezde



Spektri zvezd



Spektri zvezd: temperatura

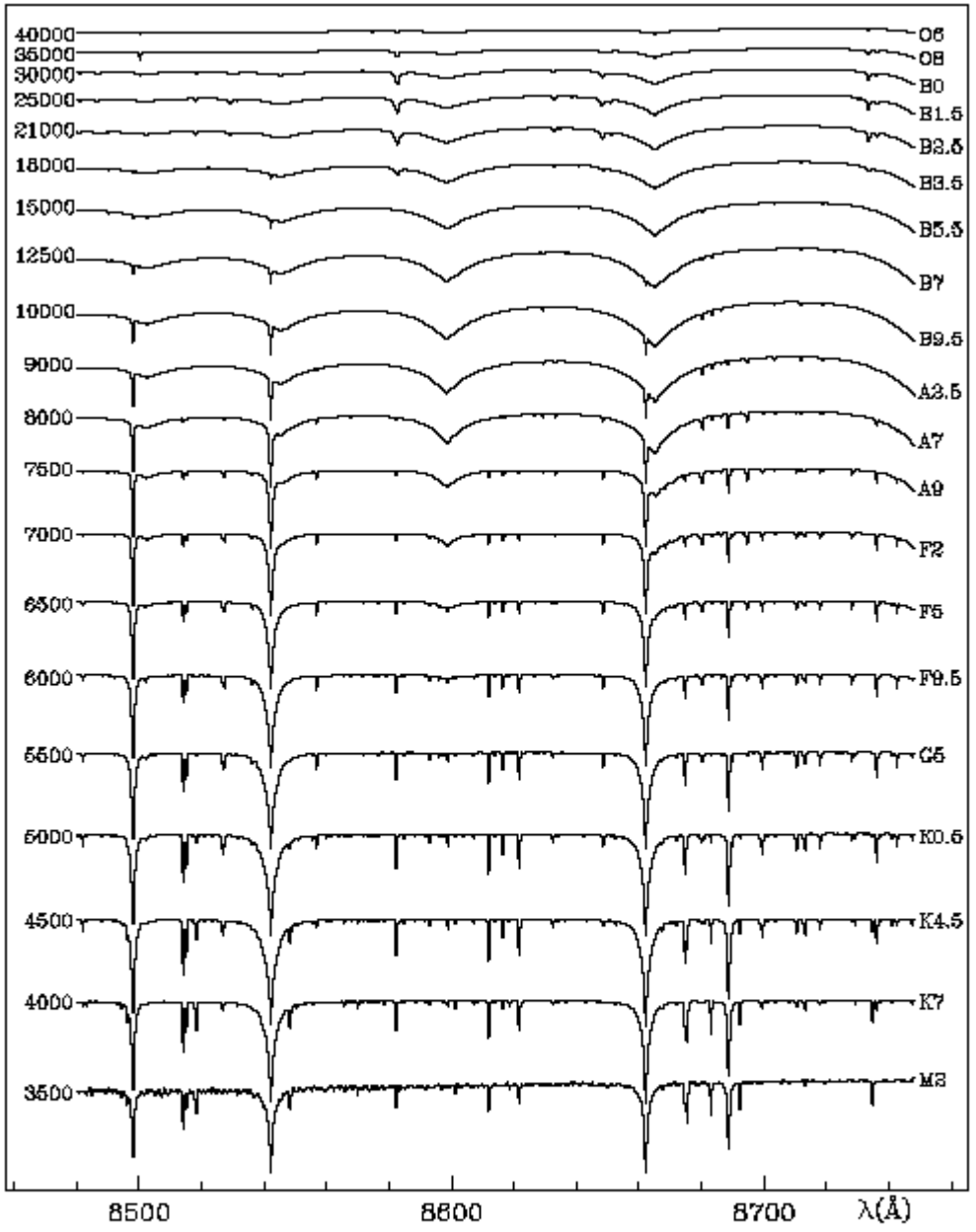
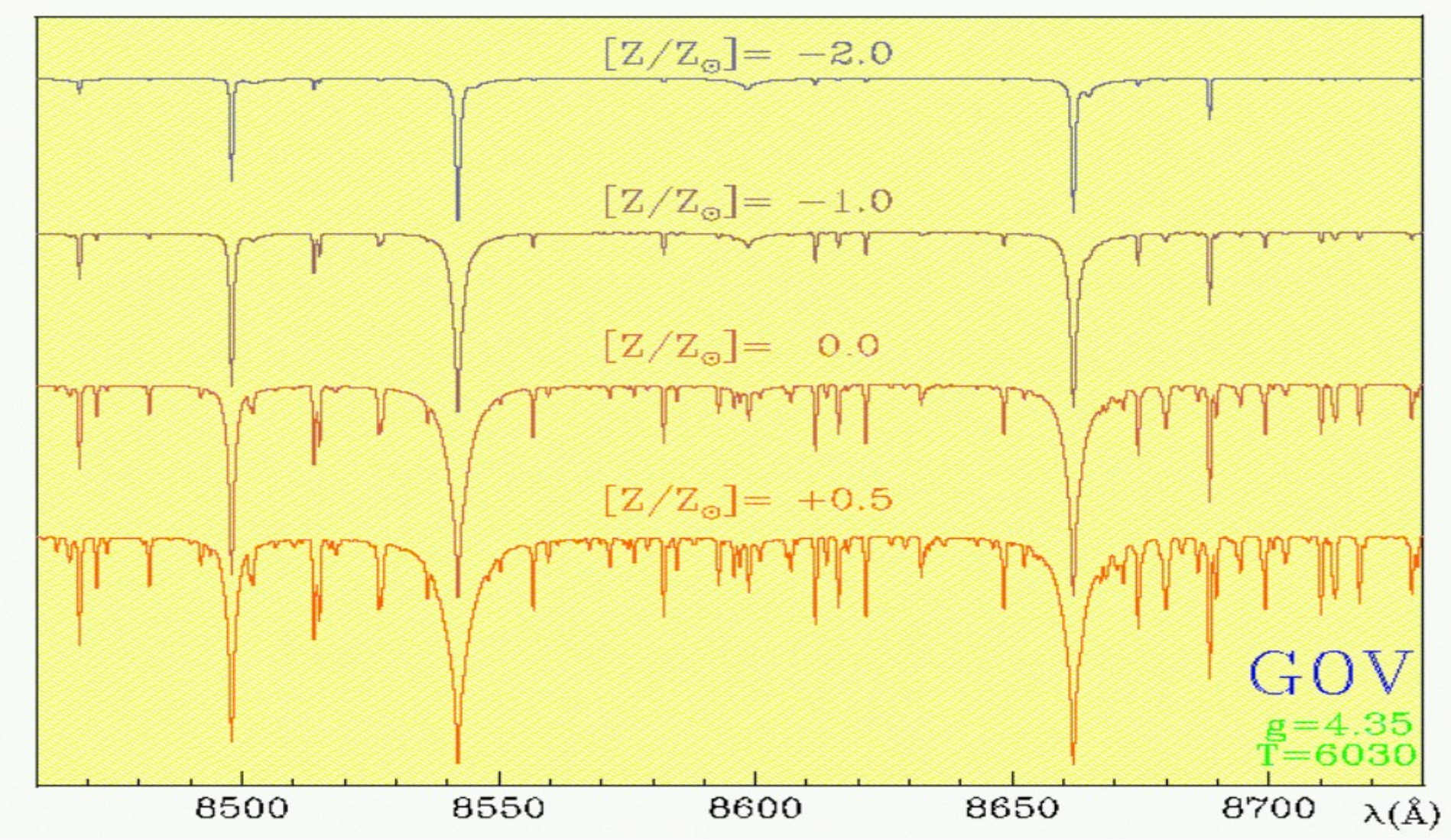
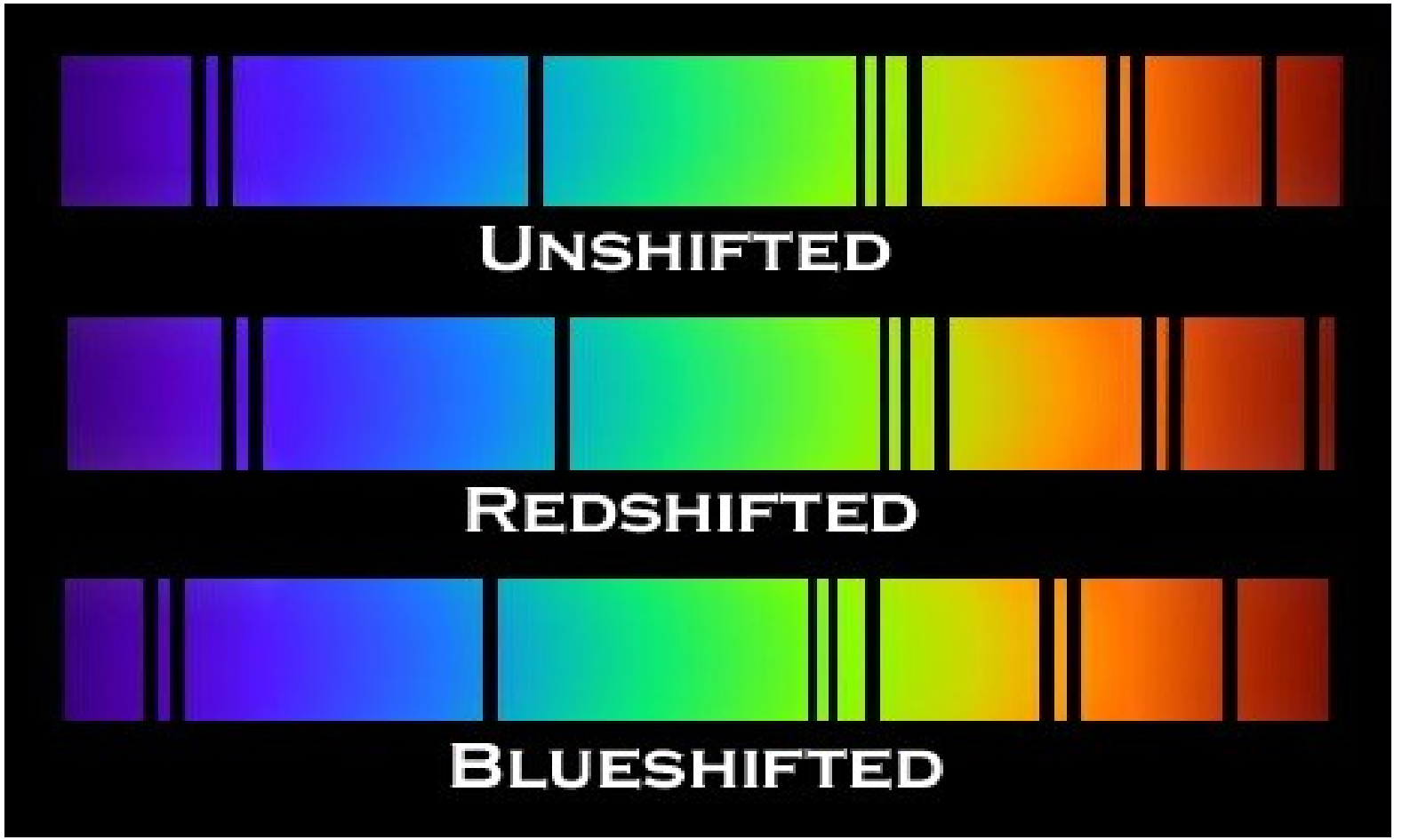


Fig. 2. Sequence of synthetic spectra (from Munari & Castelli 2000, Castelli & Munari 2001) illustrating the variations along the main sequence (T_{eff} in K on the left and corresponding spectral type for luminosity class V on the right) for moderately metal poor stars ($[Z/Z_{\odot}]=-0.5$). All spectra are on the same ordinate scale, only displaced in their zero-points.

Spektri zvezd: kemična sestava



Spektri zvezd: radialna hitrost



Spektri zvezd: projecirana hitrost vrtenja

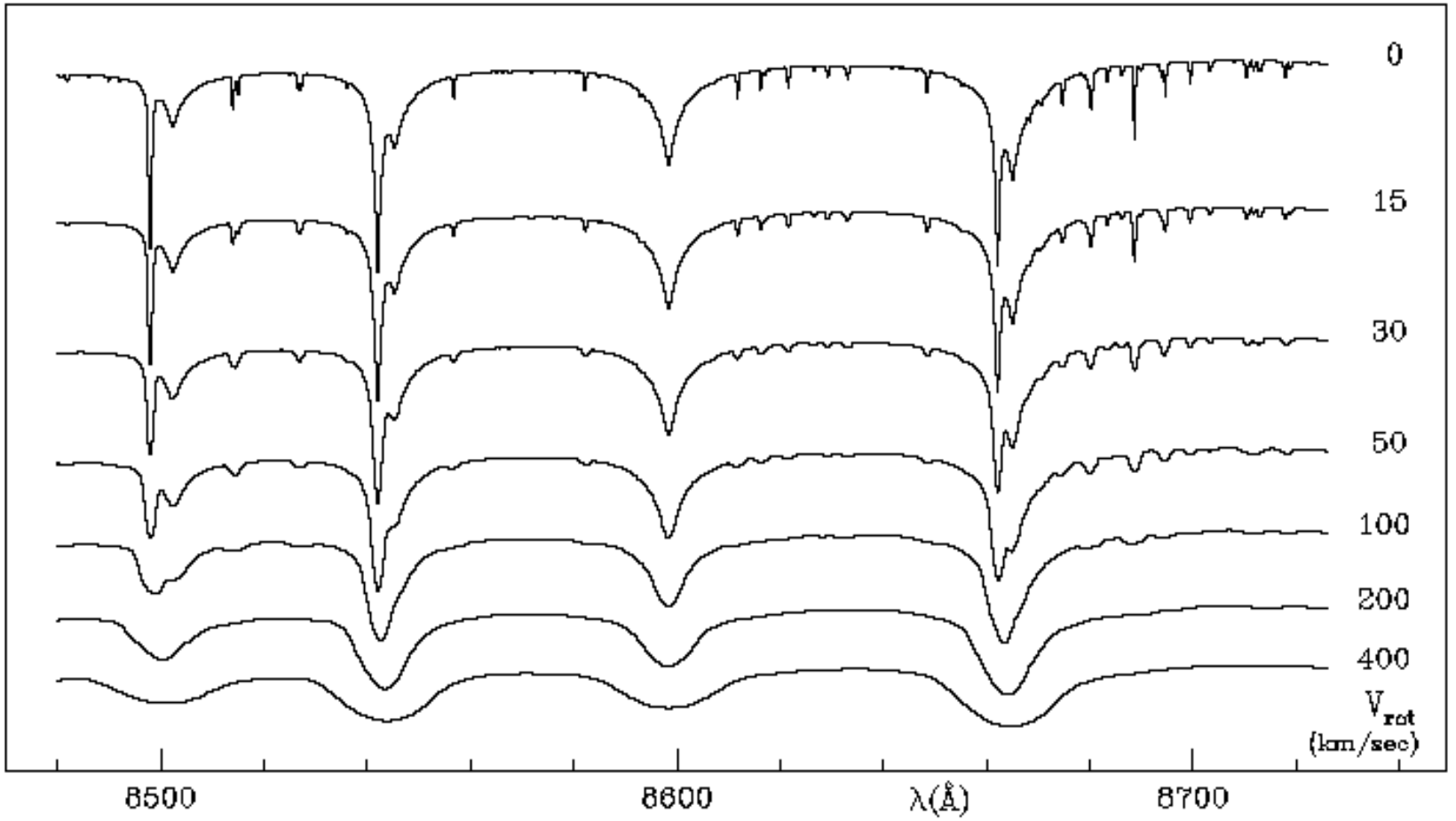


Fig. 7. Rotational velocity sequence for F0 III giants (spectra from Zwitter et al. 2001).

Spektri zvezd

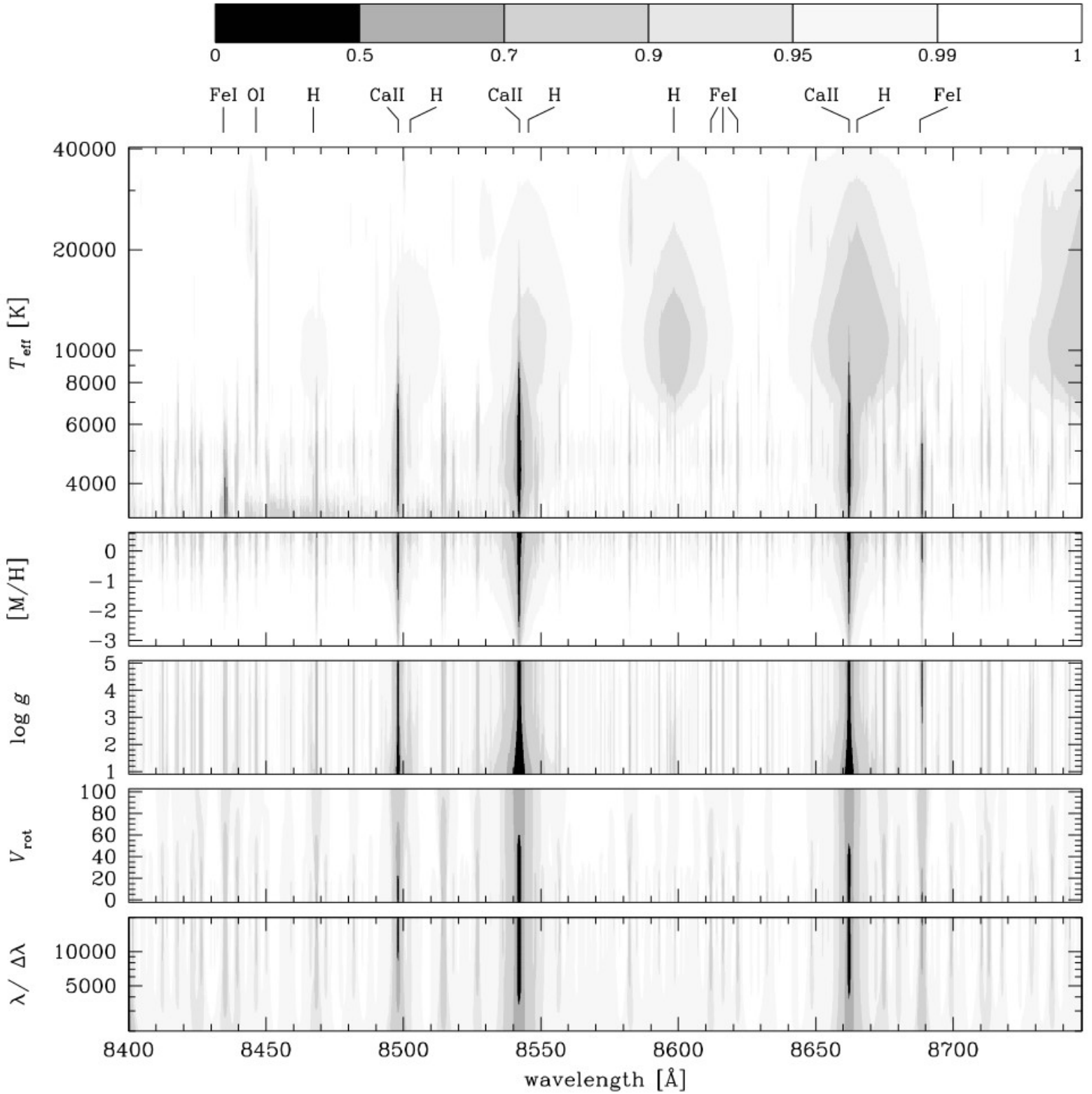
temperatura

kemična sestava

gravitacijski pospešek

projekcija hitrosti rotacije

resolucijska moč

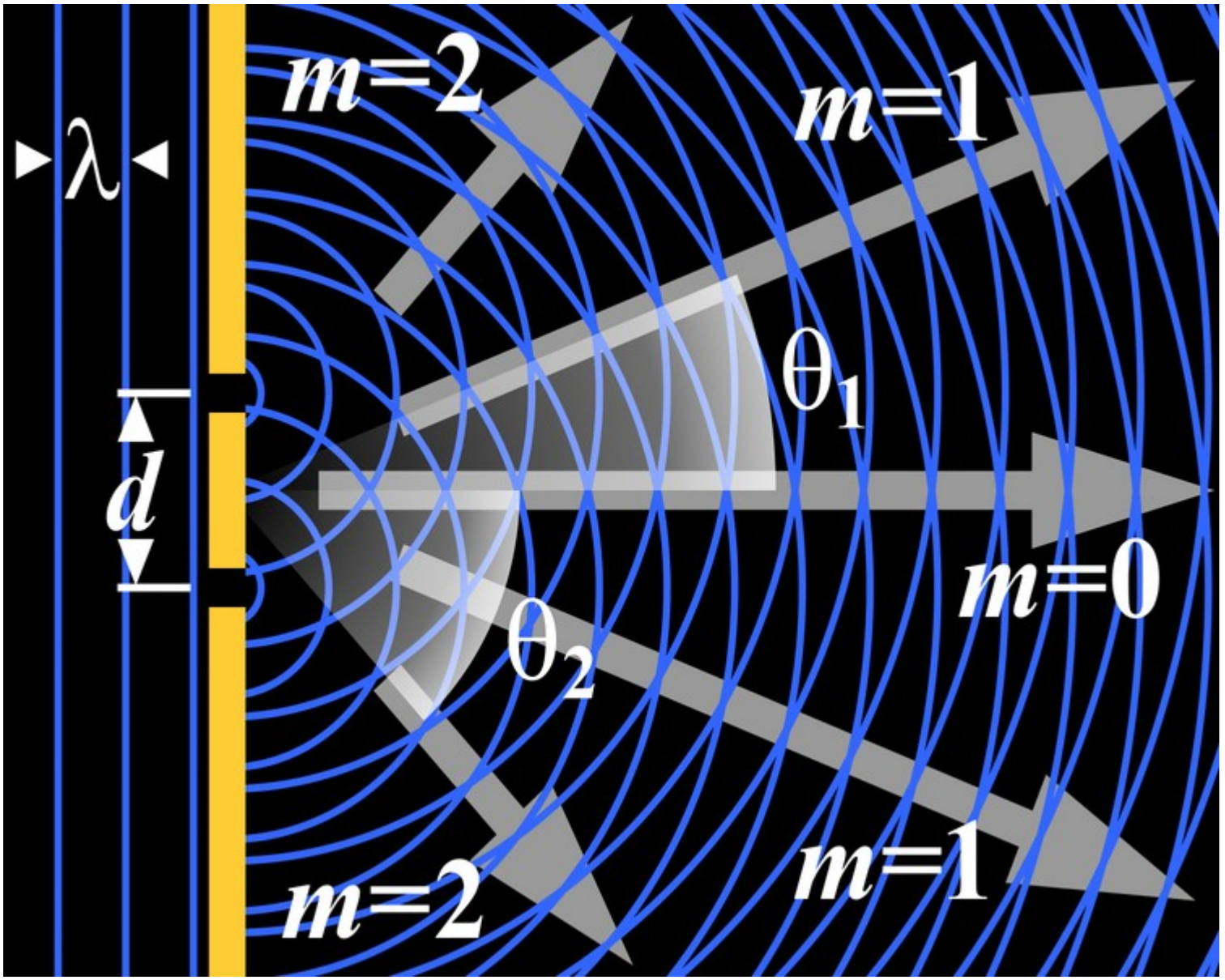


Spektrograf: smer žarka postane odvisna od valovne dolžine svetlobe

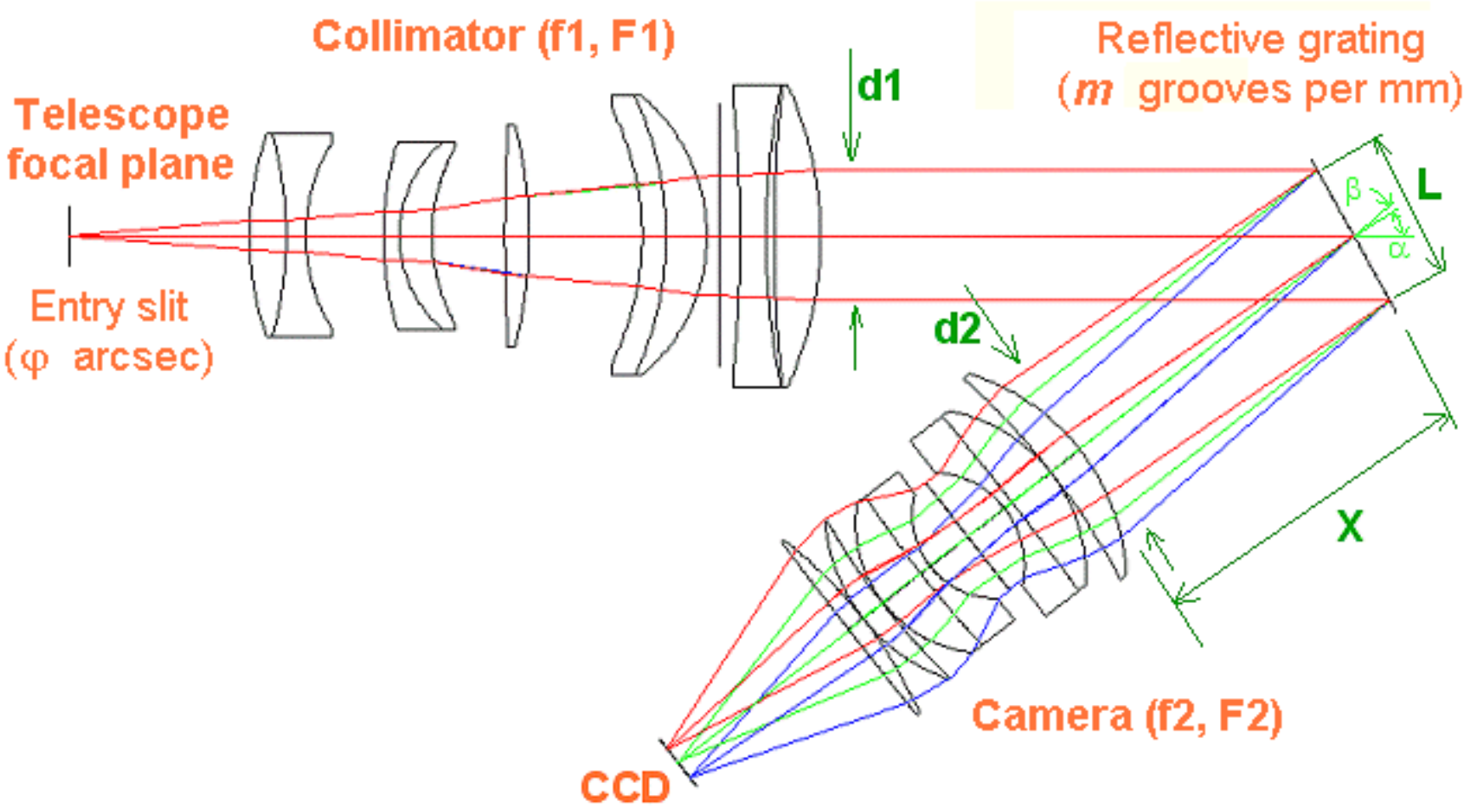
Če primerjamo spremembo smeri žarkov pri valovnih dolžinah 480 in 650 nm,
Potem ko gredo skozi razklonilni element:

Pri **prizmi** sta smeri tipično razmaknjeni za 0,6 stopinje.

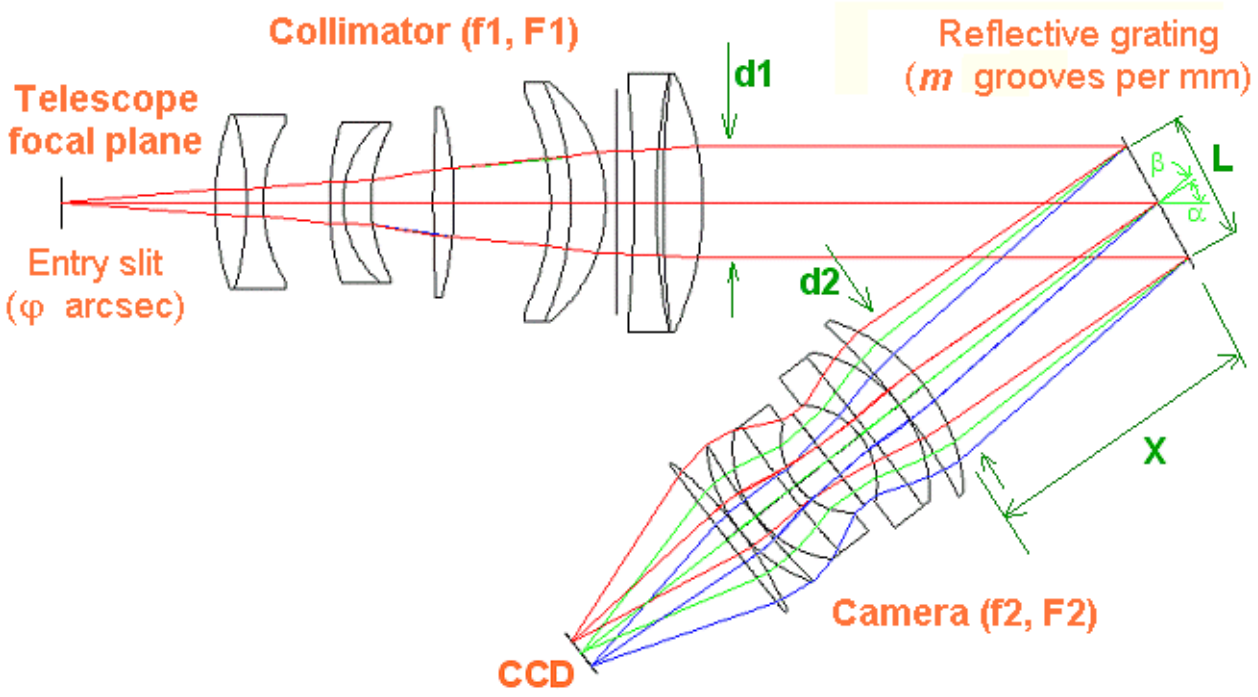
Pri **uklonski mrežici** s 1800 režami na milimeter sta smeri tipično razmaknjeni za 20 stopinj.


m=2
m=1
λ
θ1
d
m=0
θ2
m=1
m=2

Osnovna shema



Equations (1)



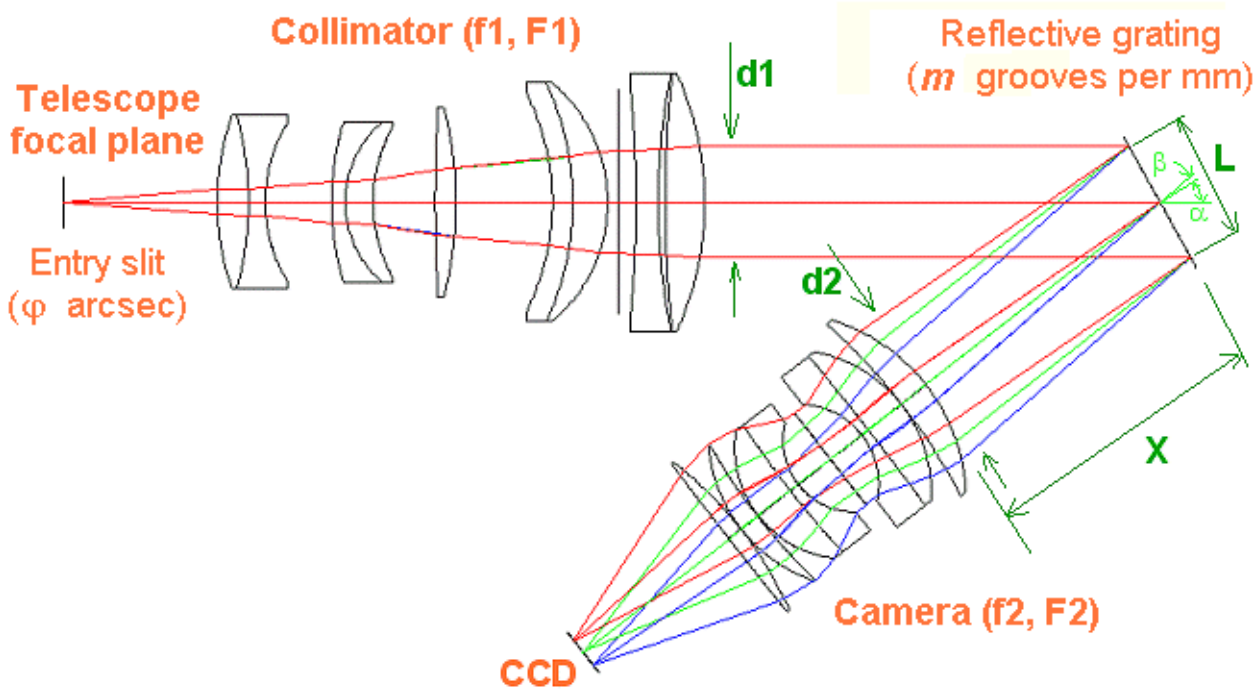
$$\sin\alpha + \sin\beta = km\lambda_o \quad ; \quad k = \pm 1,$$

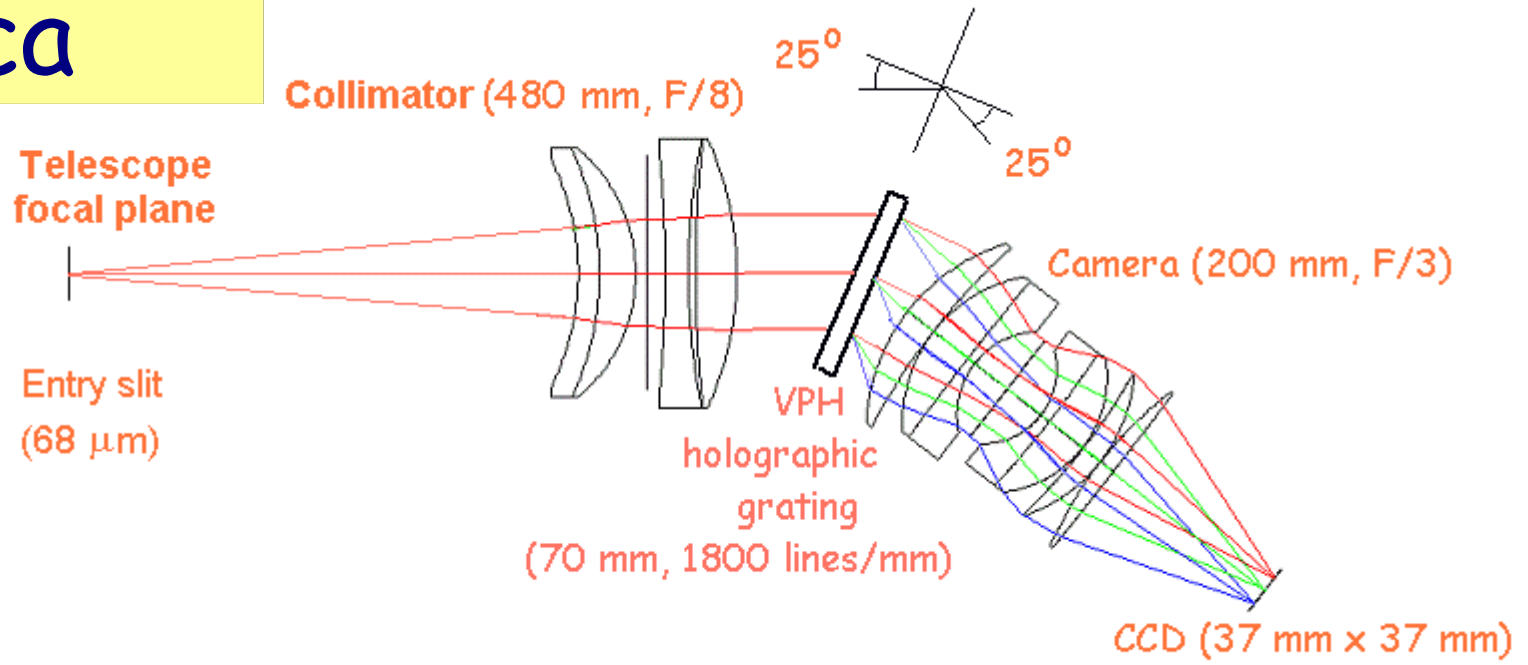
$$\gamma = \alpha - \beta$$

$$SGN(\alpha) = SGN(\beta) \;\; IF \;\; (\text{on same side of normal})$$

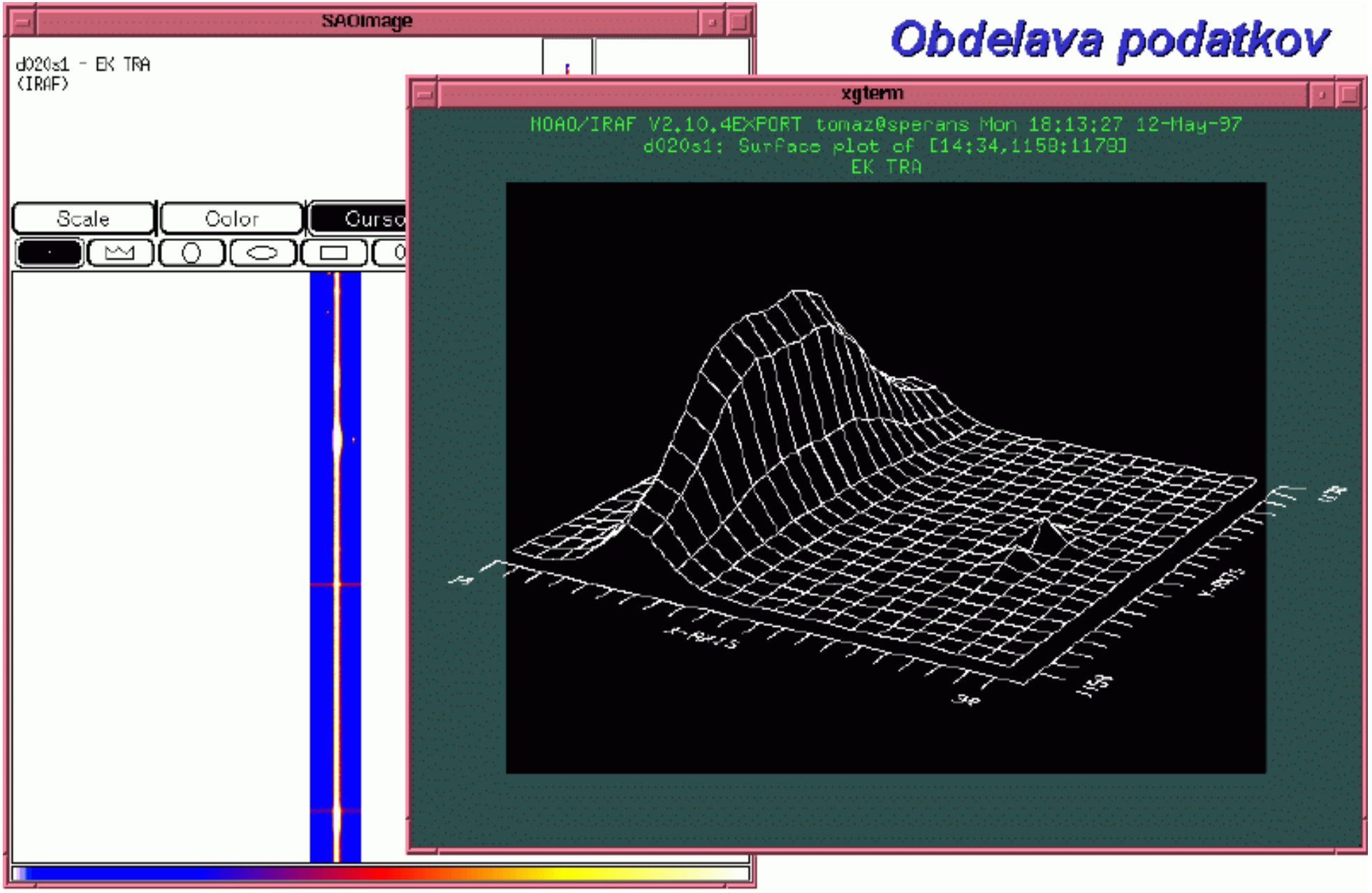
$$\sin(\alpha - \gamma/2) = \frac{km\lambda_o}{2\cos(\gamma/2)}$$

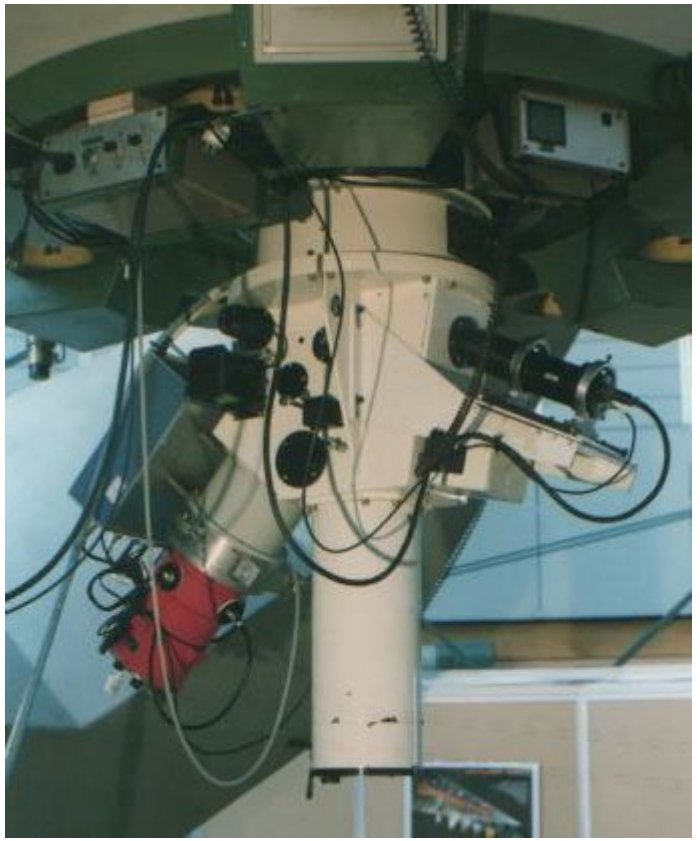
Odbojna in transmisijska uklonska mrežica

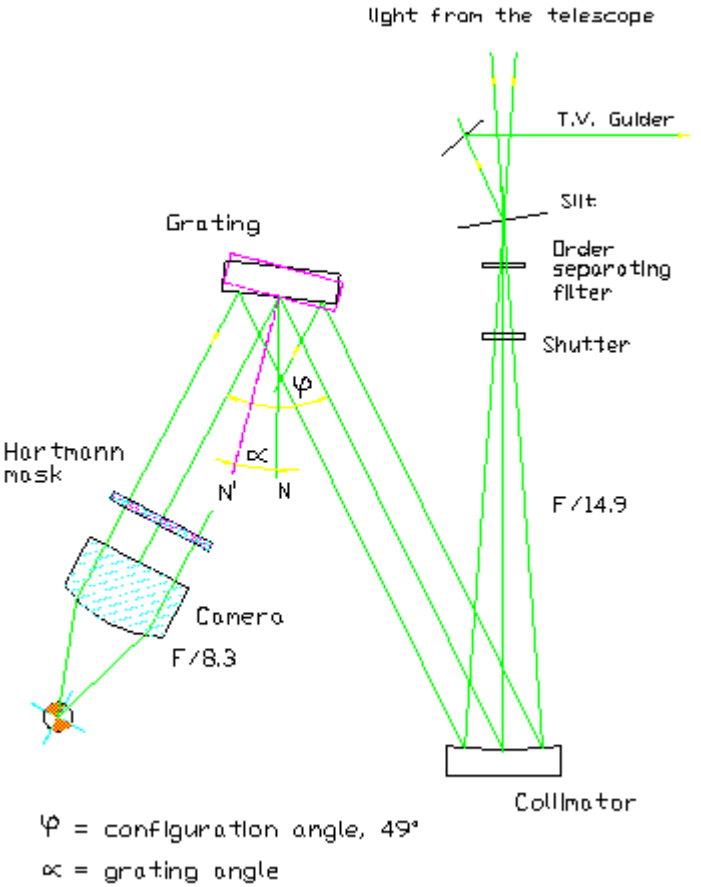




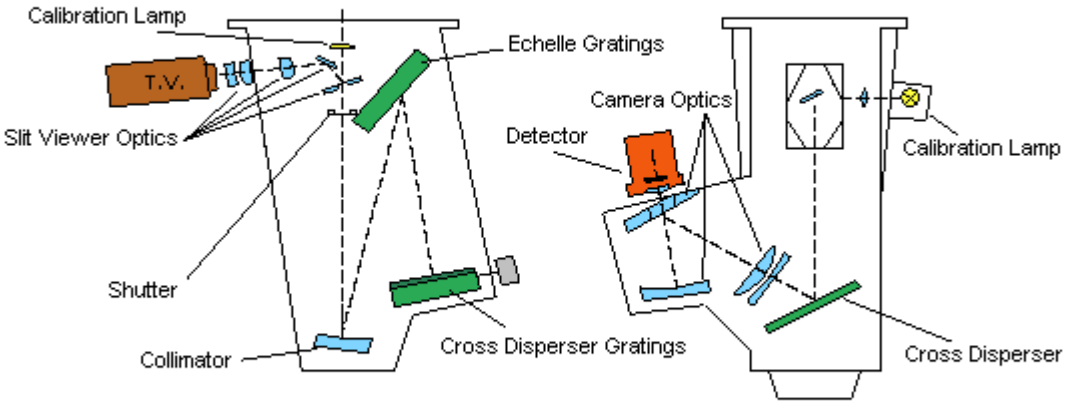
Obdelava podatkov

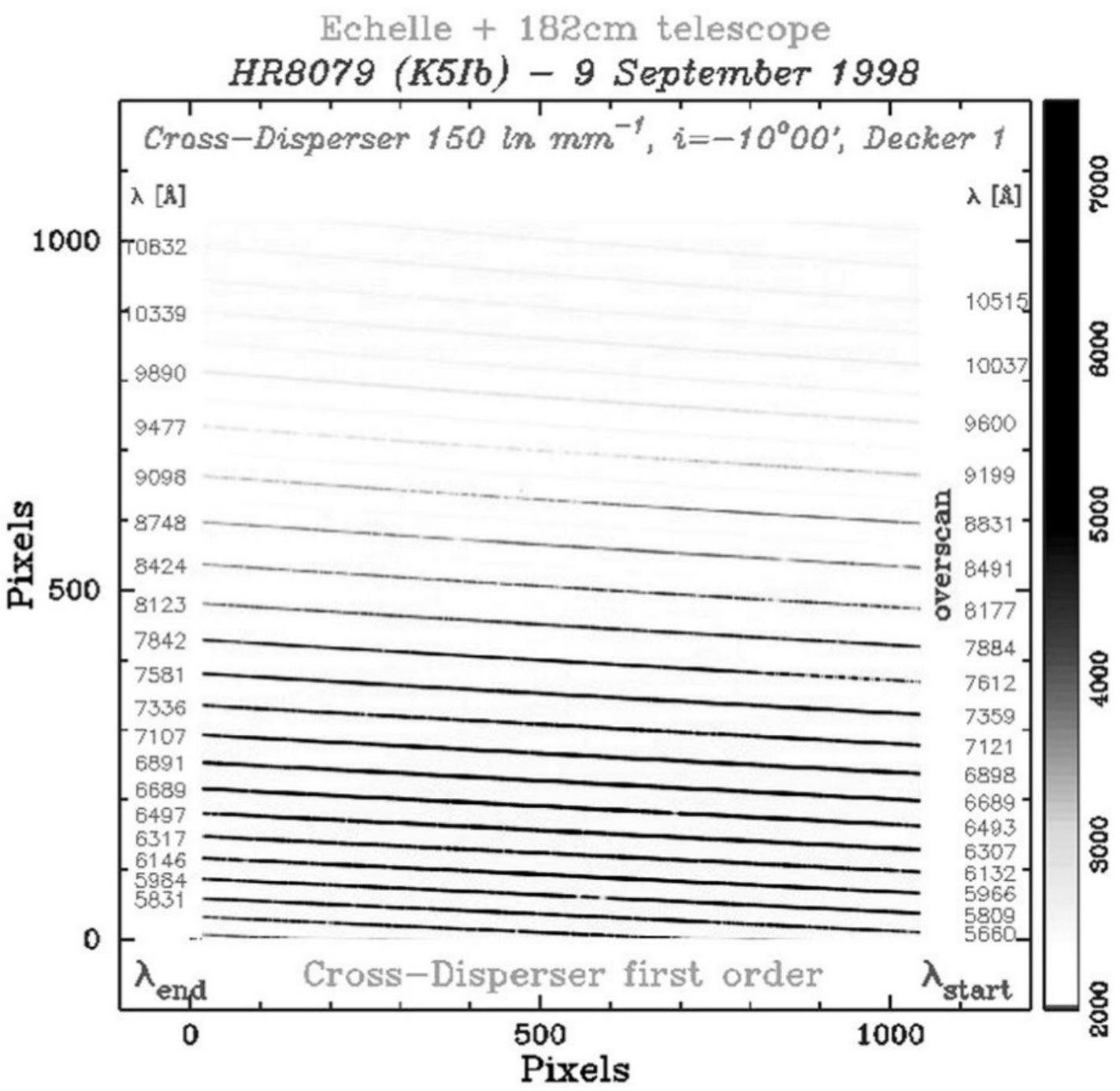




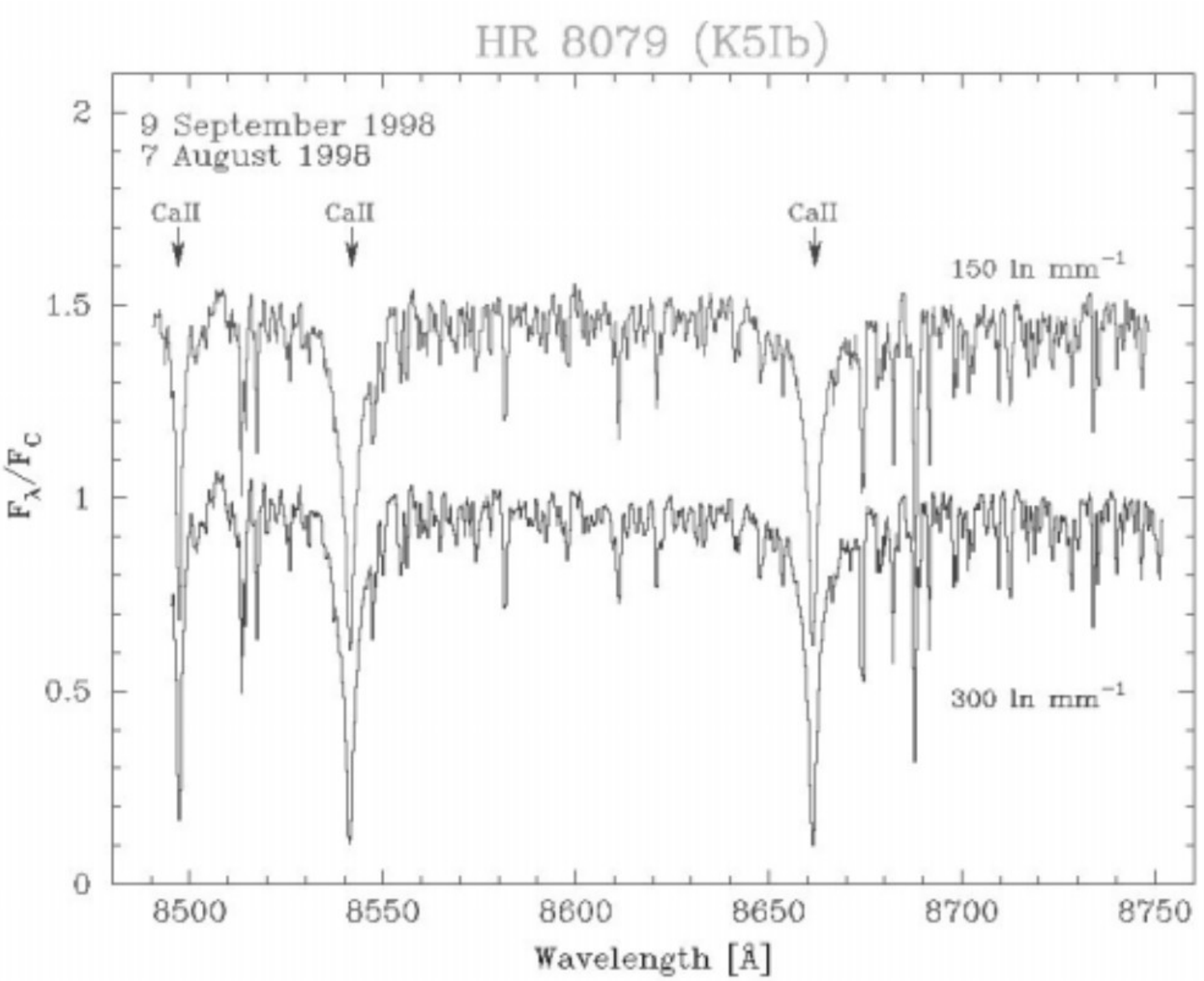


Boller-Chivensov in echellov spektrograf

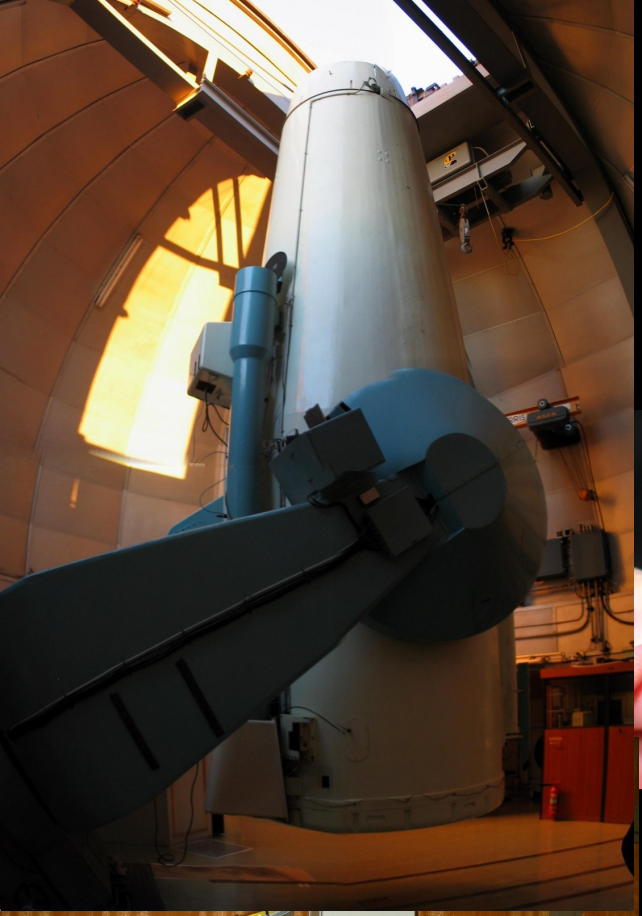


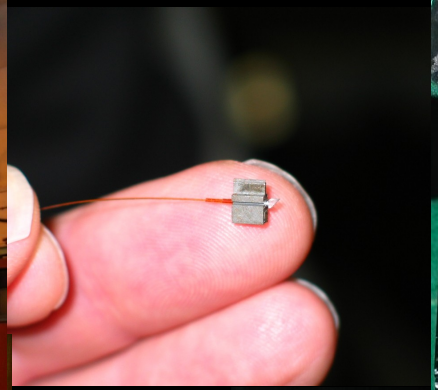


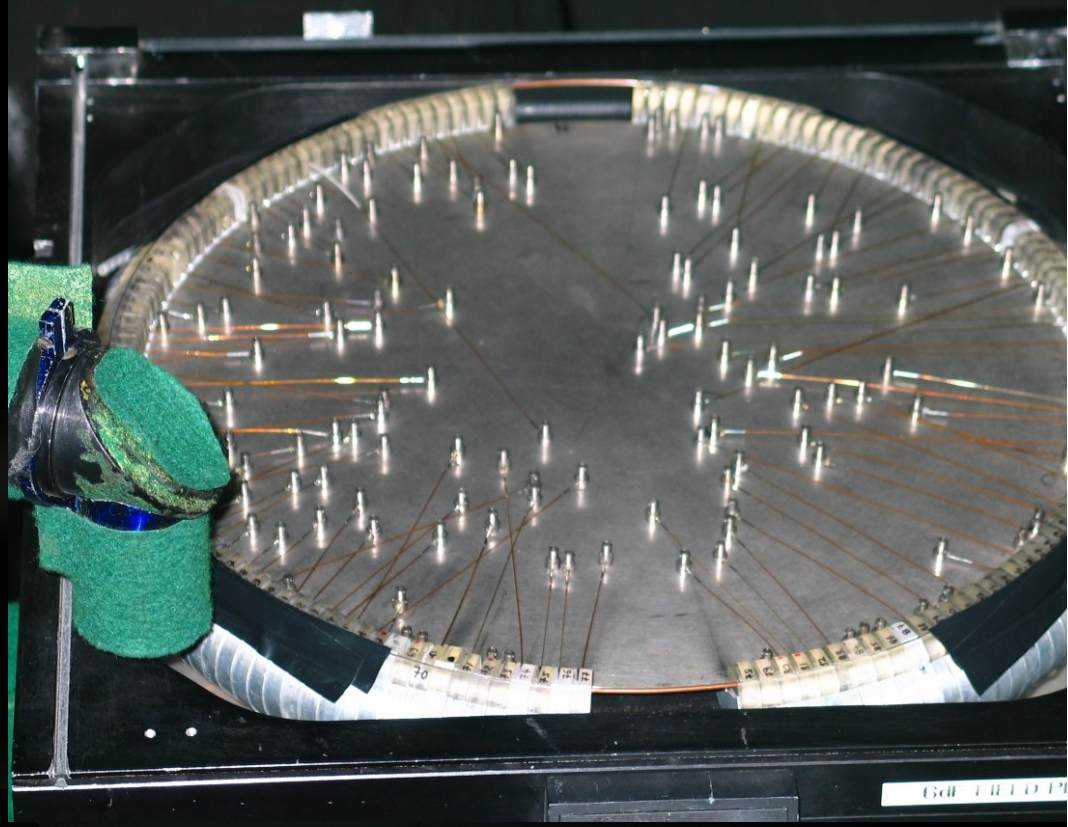
Spectrum of the cool star HR 8079 (K5Ib, V=3.7 mag, 600 sec expt) without second-order suppressing filter. The low flux at the blue wavelengths of the second order spectrum reduces contamination to minimal terms.



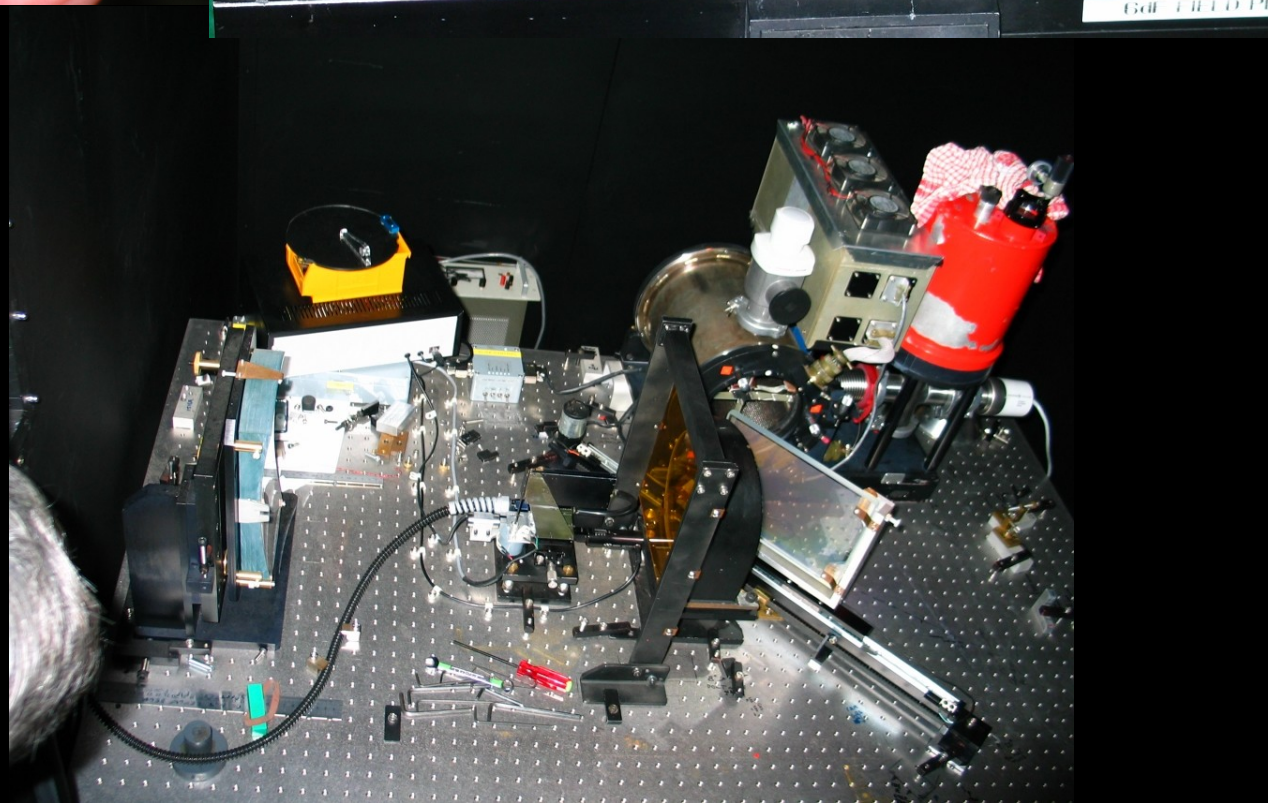
Extracted 1-D spectra of order #24 for the cool star HR 8079 (K5Ib, cf. figures at pag. 4). The steep red continuum slope prevents contamination from second order spectrum.








64F
Box



Multifiber spectra: arc, flat & object

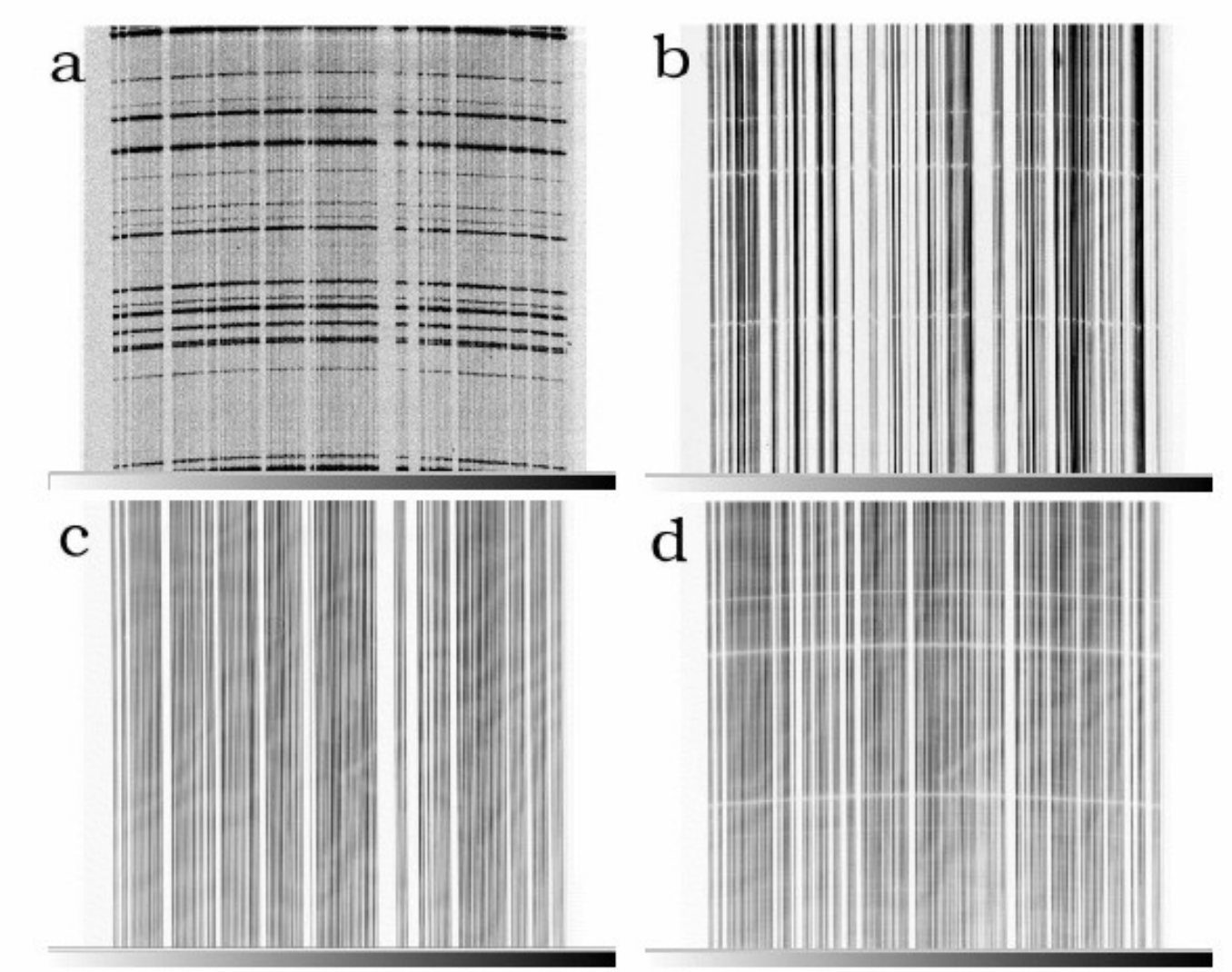
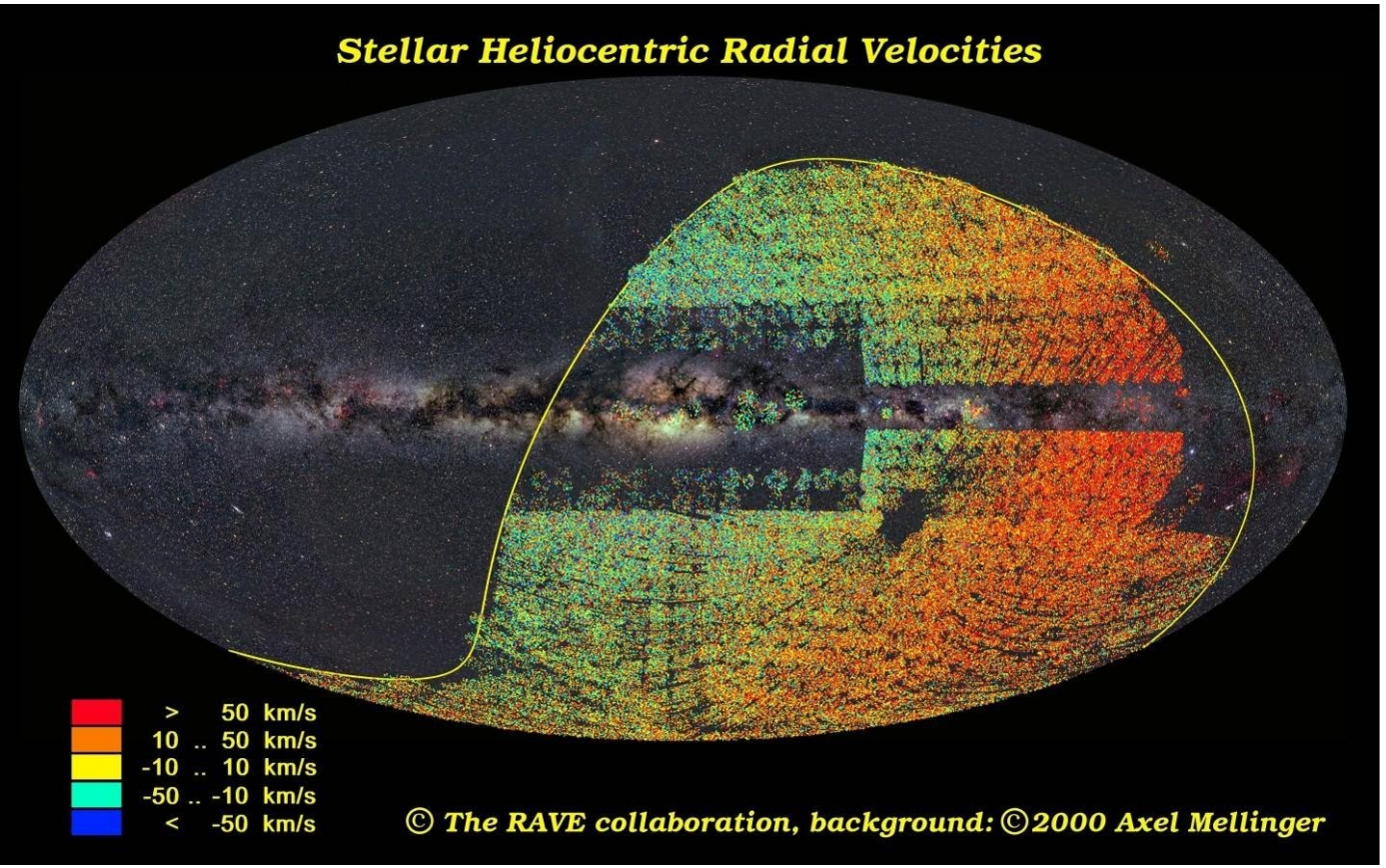
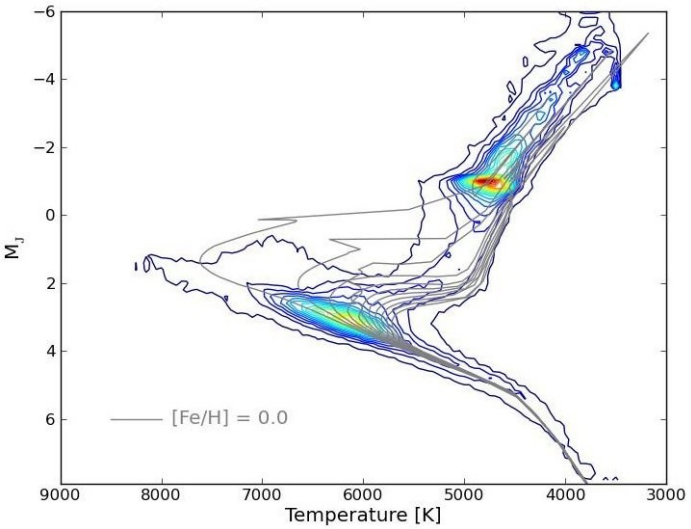


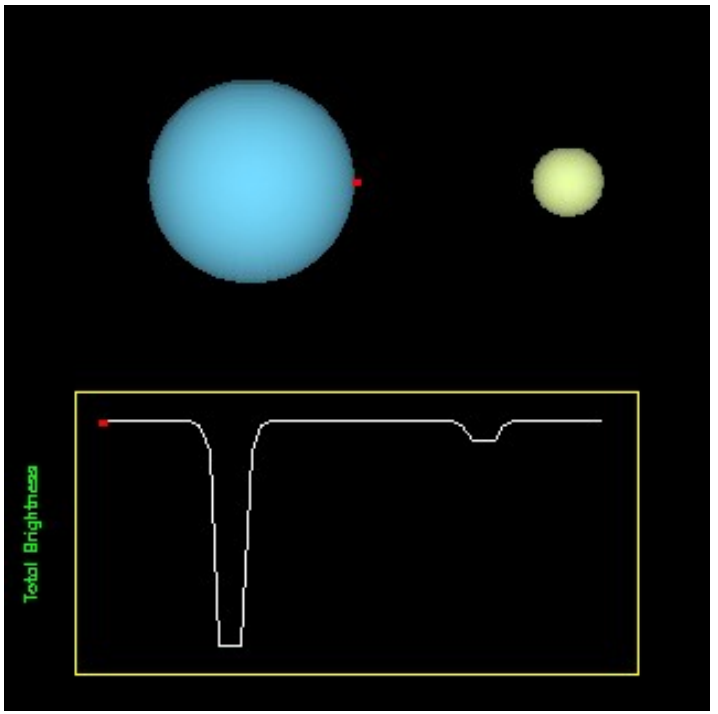
Figure 1: Identification of different kinds of files by visual inspection with the IRAF's *display* command: (a) an arc exposure, (b) a scientific exposure, (c) a useful flat-field, (d) a bad flat-field. The latter should not be used because the Ca II absorption lines of unknown (but local) origin would jeopardize flux calibration. In the text we refer to the horizontal or x-direction as across-dispersion, vertical or y-direction is along-dispersion.

RAdialnohitrostni Vesoljski Eksperiment (RAVE)

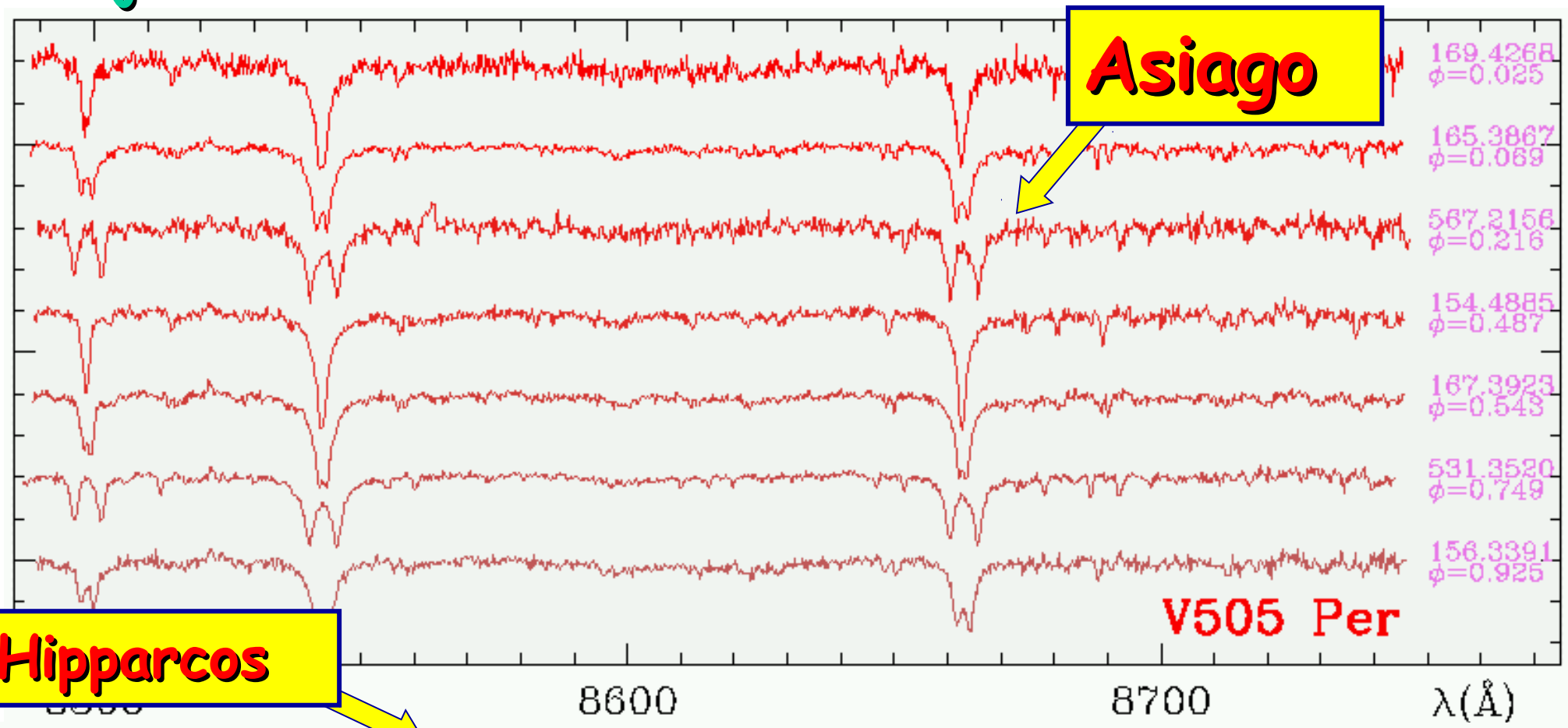




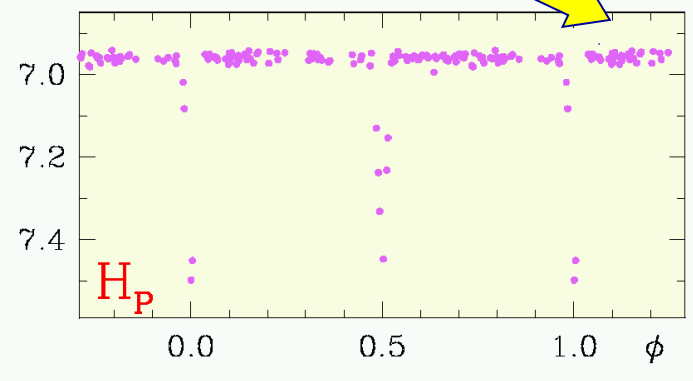
Dvojne zvezde

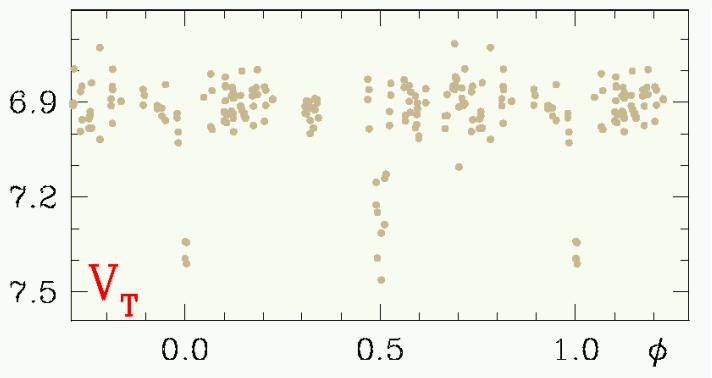


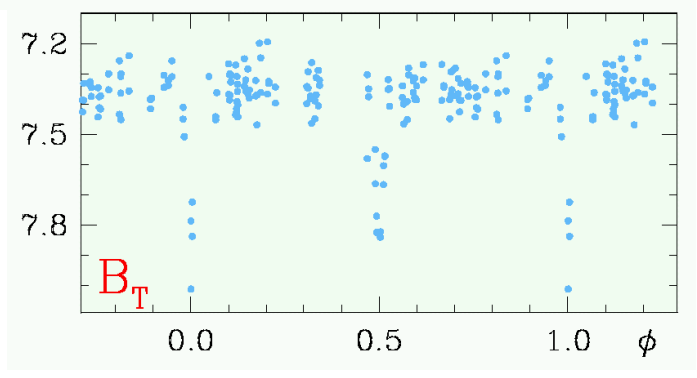
Dvojne zvezde

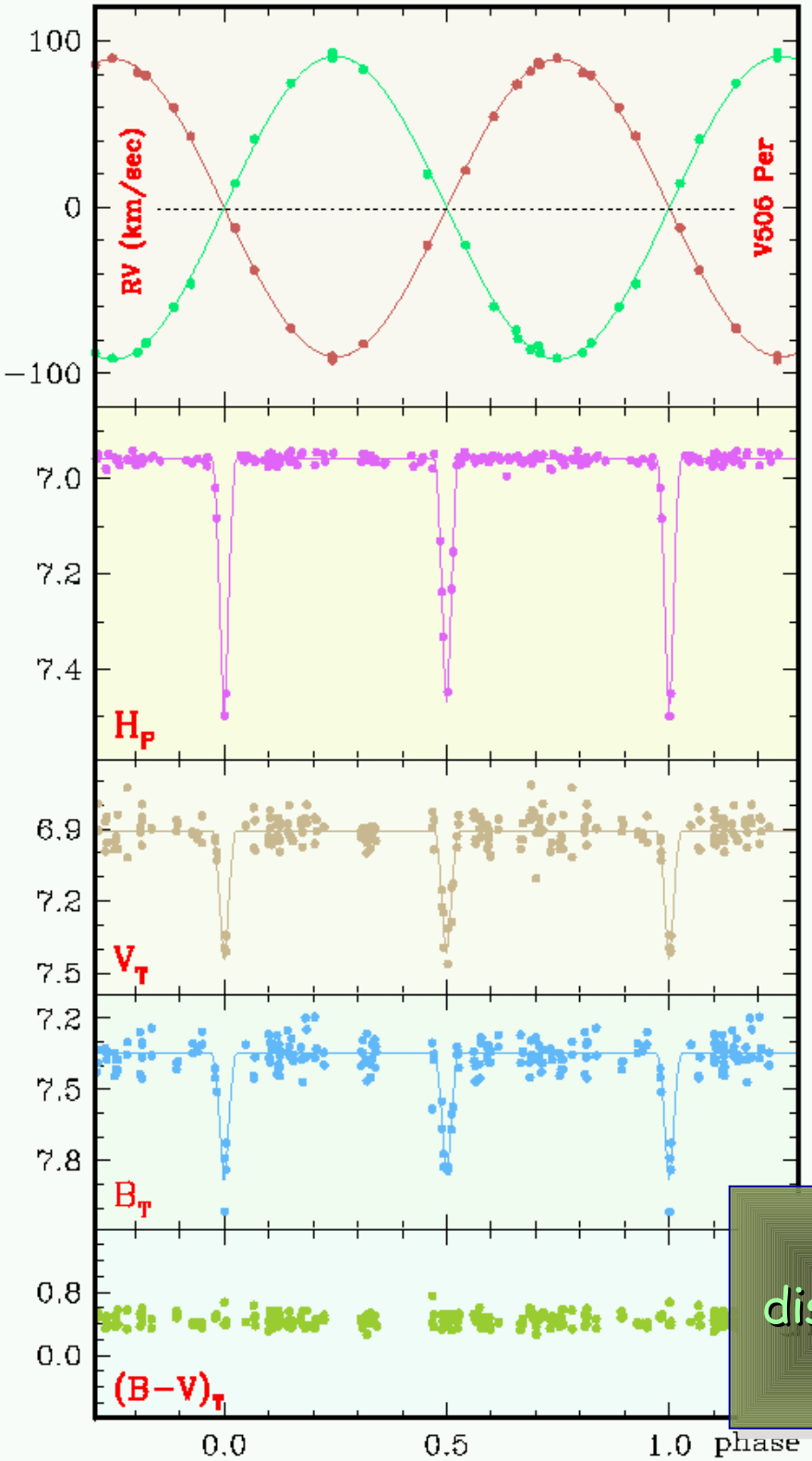


Hipparcos









$a = 15.06 \pm 0.08\ R_o$

$M_1 = 1.30 \pm 0.02\ M_o$
$M_2 = 1.28 \pm 0.02\ M_o$

$R_1 = 1.40 \pm 0.02$ Ro
$R_2 = 1.14 \pm 0.03$ Ro

$T_1 = 6460 \pm 50$ K
$T_2 = 6415 \pm 50$ K

$M_{bol,\,1} = 3.60 \pm 0.04$
$M_{bol,\,2} = 4.04 \pm 0.05$

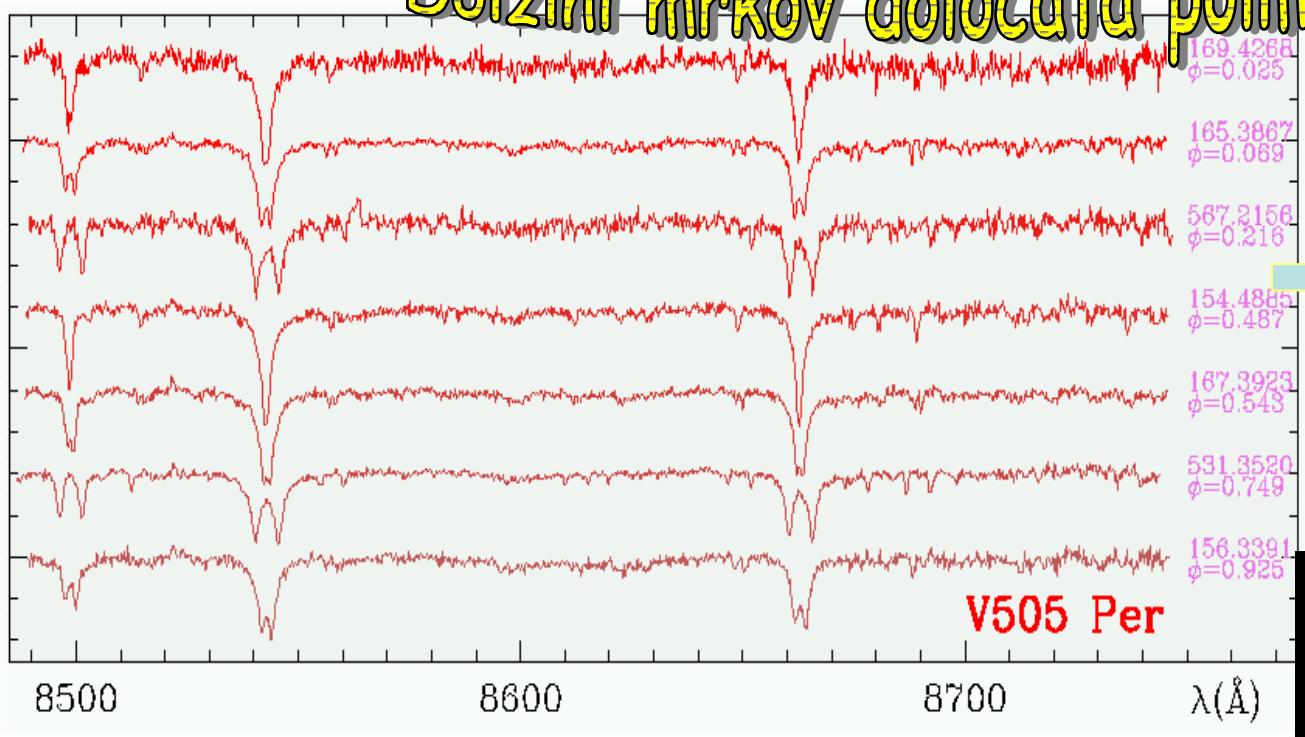
$\sigma_{RV} = 1.5, 2.5$ km/sec

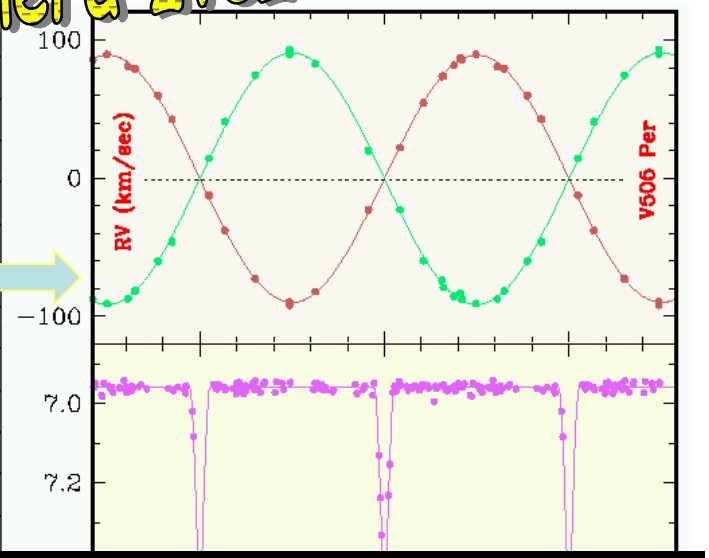
$\sigma_{HP} = 0.009$ mag
$\sigma_{VT} = 0.10$ mag
$\sigma_{BT} = 0.09$ mag

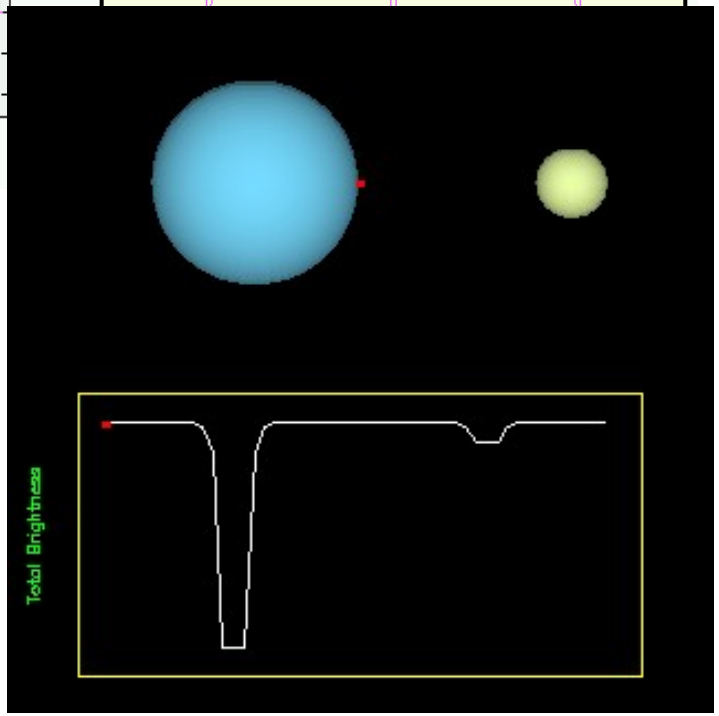
distance: 66 +/- 4 pc Hipparcos
60 +/- 3 pc Asiago/GAIA
62 +/- 2 pc Marshall et al.

Prekrivalne dvojne zvezde

Dolžini mrkov določata polmera zvezd







a = 15.06 +/- 0.08 R_o

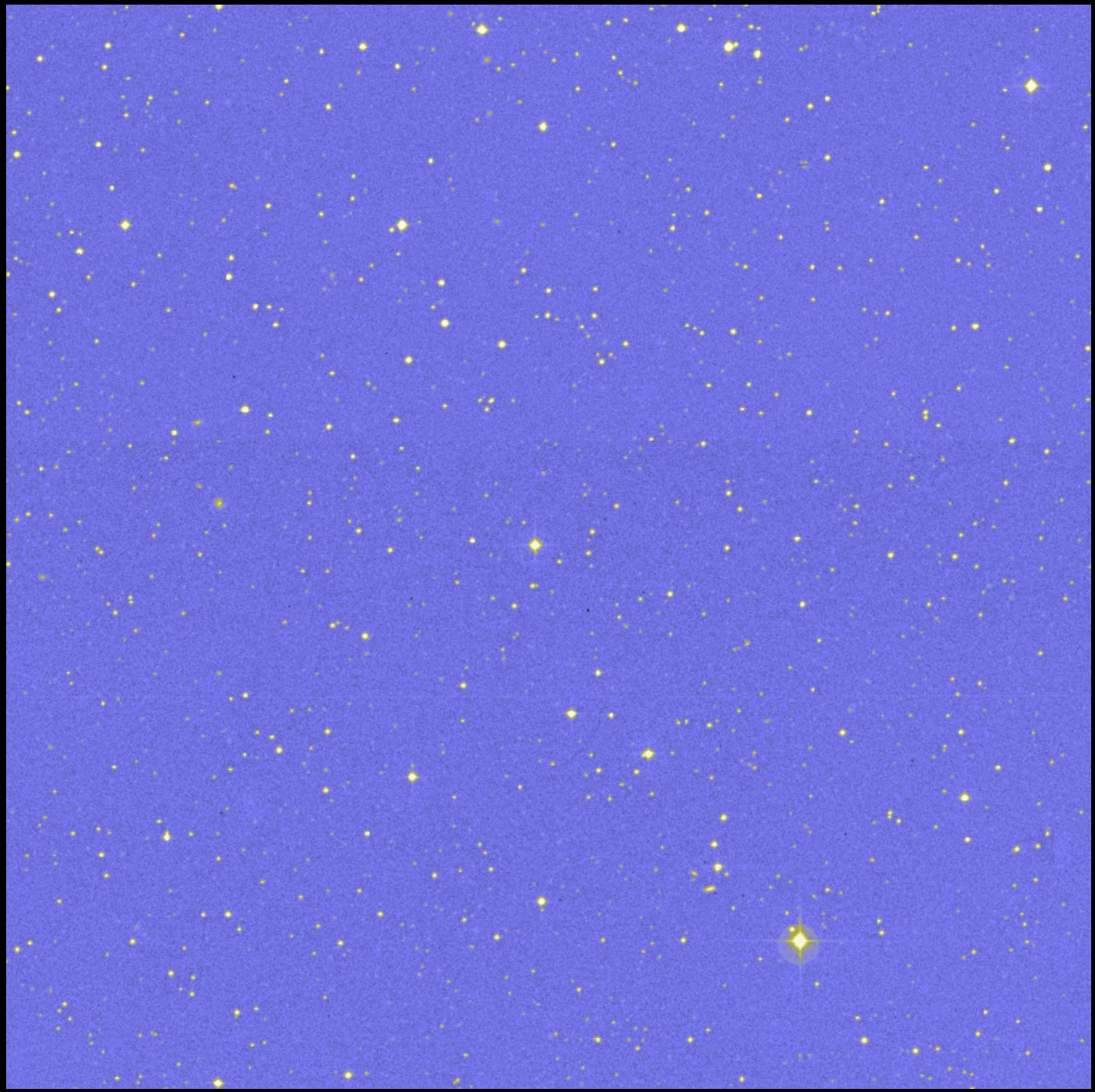
M_1 = 1.30 +/- 0.02 M_o
M_2 = 1.28 +/- 0.02 M_o

R_1 = 1.40 +/- 0.02 Ro
R_2 = 1.14 +/- 0.03 Ro

T_1 = 6460 +/- 50 K
T_2 = 6415 +/- 50 K

razdalja: 60 +/- 3 pc Asiago/GAIA
66 +/- 4 pc Hipparcos

Zvezda HO Tehtnice



Zvezda HO Tehtnice

50 opazovanj, točnost 0,9 m/s

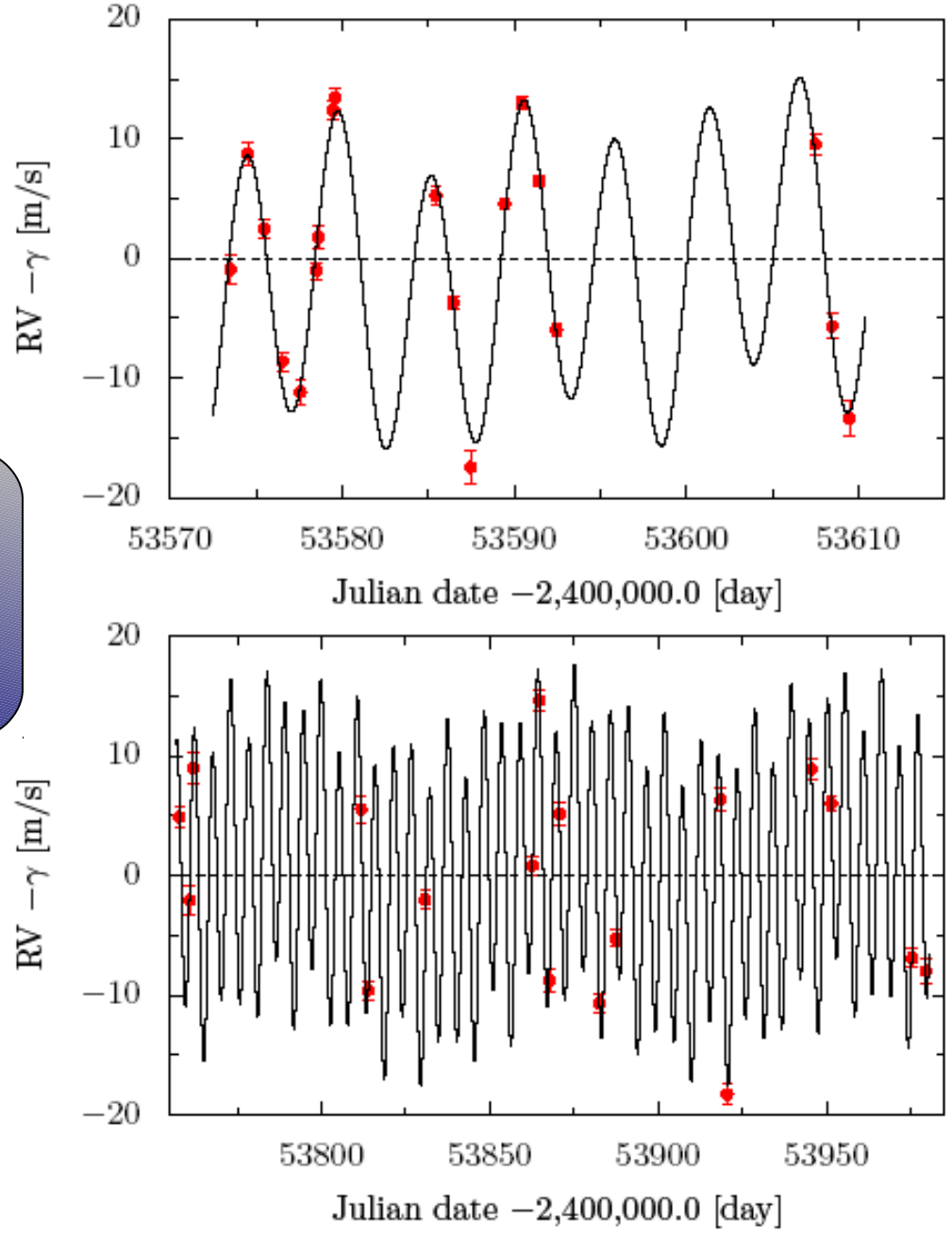


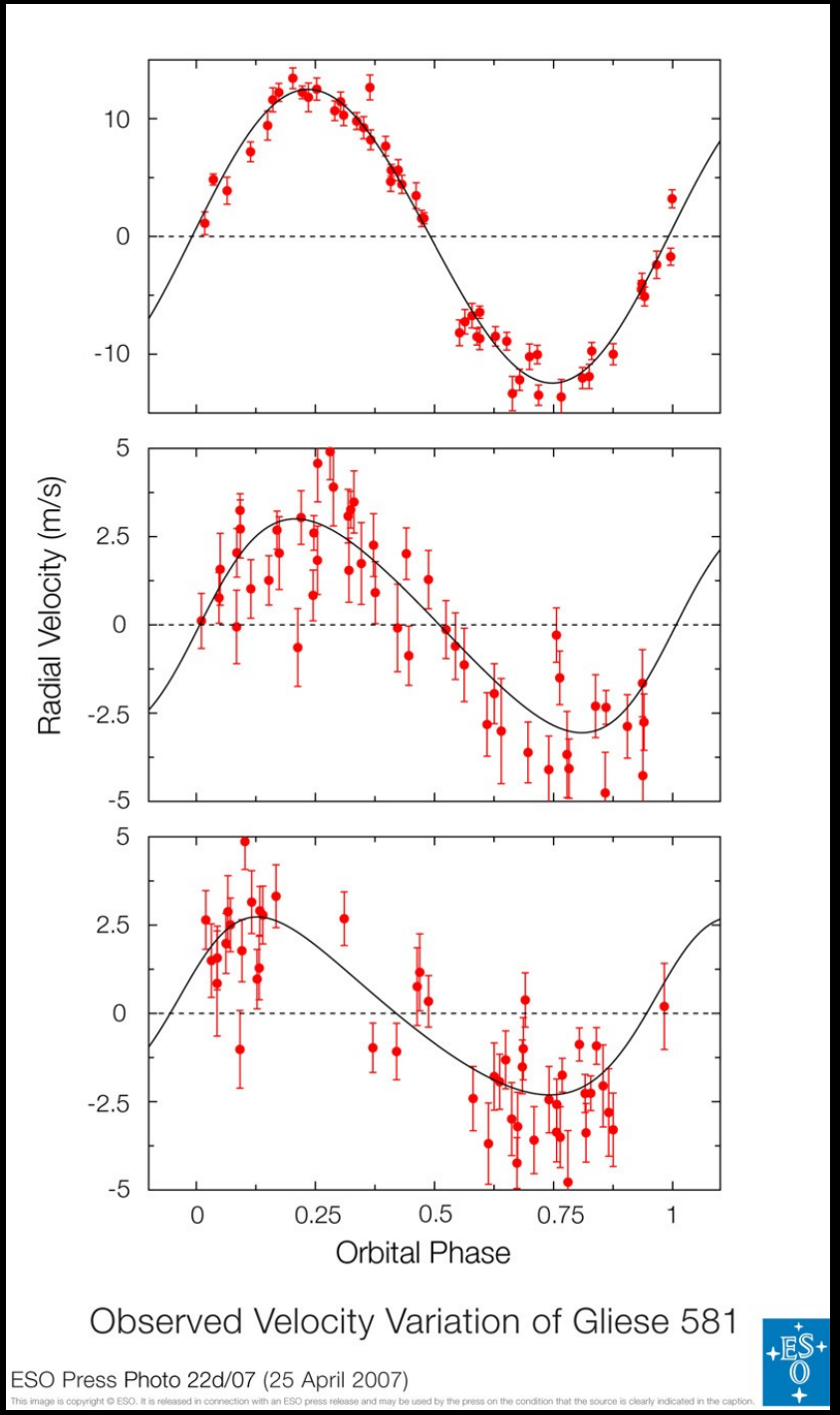
Fig. 4. Temporal display of the 3-planet Keplerian model of Gl 581, on time intervals with dense observational sampling.

Zvezda HO Tehtnice

prvi planet

drugi planet

tretji planet



Zvezda HO Tehtnice

Table 1. Orbital and physical parameters derived from 3-planet Keplerian models of Gl 581 for the free-eccentricity and circular cases. Uncertainties are directly derived from the covariance matrix.

Parameter		Circular case			Free eccentricity case		
		Gl 581 b	**Gl 581 c**	**Gl 581 d**	**Gl 581 b**	**Gl 581 c**	**Gl 581 d**
P	[days]	5.3687±0.0003	12.931±0.007	83.4±0.4	5.3683±0.0003	12.932±0.007	83.6±0.7
T	[JD-2400000]	52999.99±0.05	52996.74±0.45	52954.1±3.7	52998.76±0.62	52993.38±0.96	52936.9±9.2
e		0.0 (fixed)	0.0 (fixed)	0.0 (fixed)	0.02±0.01	0.16±0.07	0.20±0.10
V	[km s^{-1}]		-9.2115 ± 0.0001			-9.2116 ± 0.0002	
ω	[deg]	0.0 (fixed)	0.0 (fixed)	0.0 (fixed)	273±42	267±24	295±28
K	[m s^{-1}]	12.42 ± 0.19	3.01±0.16	2.67±0.16	12.48 ± 0.21	3.03±0.17	2.52±0.17
$a_1 \sin i$	[10^{-6} AU]	6.129	3.575	20.47	6.156	3.557	18.98
$f(m)$	[$10^{-13} M_\odot$]	10.66	0.365	1.644	10.80	0.359	1.305
$m_2 \sin i$	[$M_{\rm Jup}$]	0.0490	0.0159	0.0263	0.0492	0.0158	0.0243
$m_2 \sin i$	[$M_\oplus$]	15.6	5.06	8.3	15.7	5.03	7.7
a	[AU]	0.041	0.073	0.25	0.041	0.073	0.25
$N_{\rm meas}$			50			50	
Span	[days]		1050			1050	
σ (O-C)	[ms^{-1}]		1.28			1.23	
$\chi^2_{\rm red}$			3.17			3.45	

Zemlji podoben planet

- obhodna doba 12,9 dneva
- masa ≥ 5 Zemljinih mas
- polmer ~1,5 Zemljinih polmerov
- površinska temperatura 0 – 40 stopinj Celzija