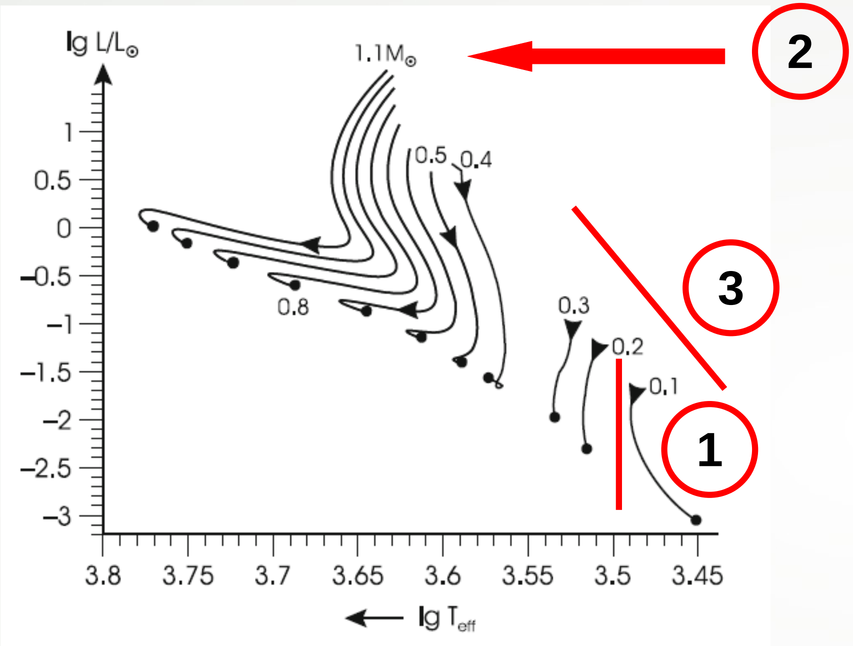
Teoretična astrofizika

razumevanje stanja in razvoja zvezd ter njihove okolice

Razvoj zvezd

Hayashijeva črta in prepovedano območje

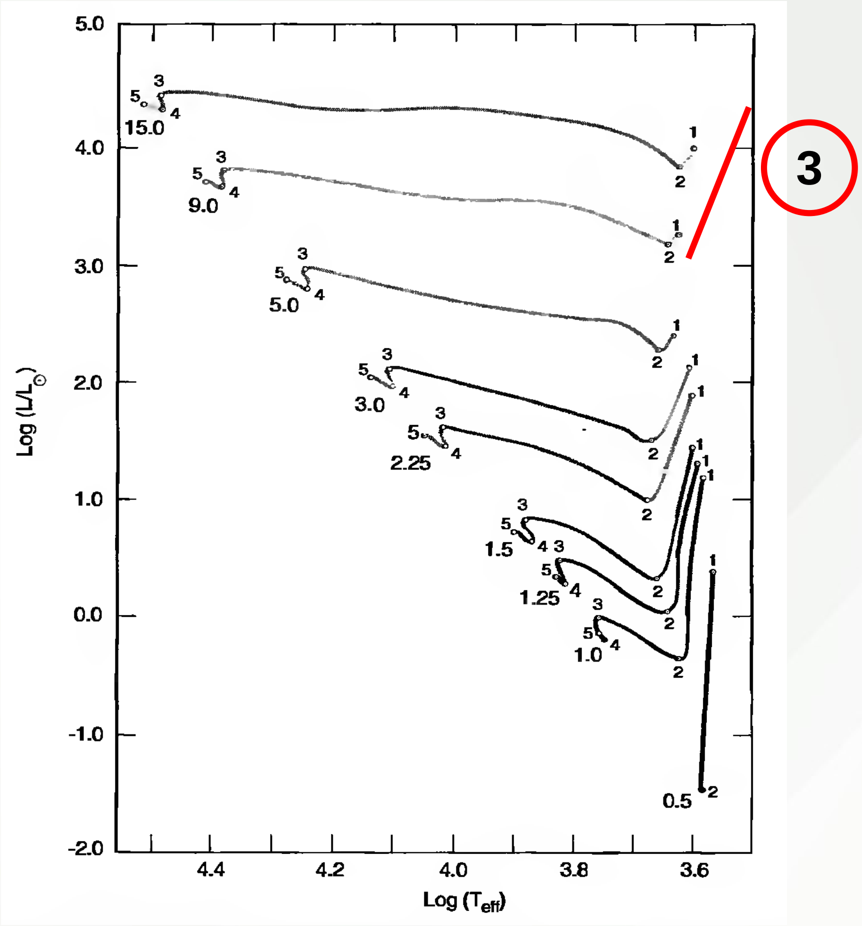


$$\boxed{\log L = A \log T_{eff} + B \log M + konst\,.}$$

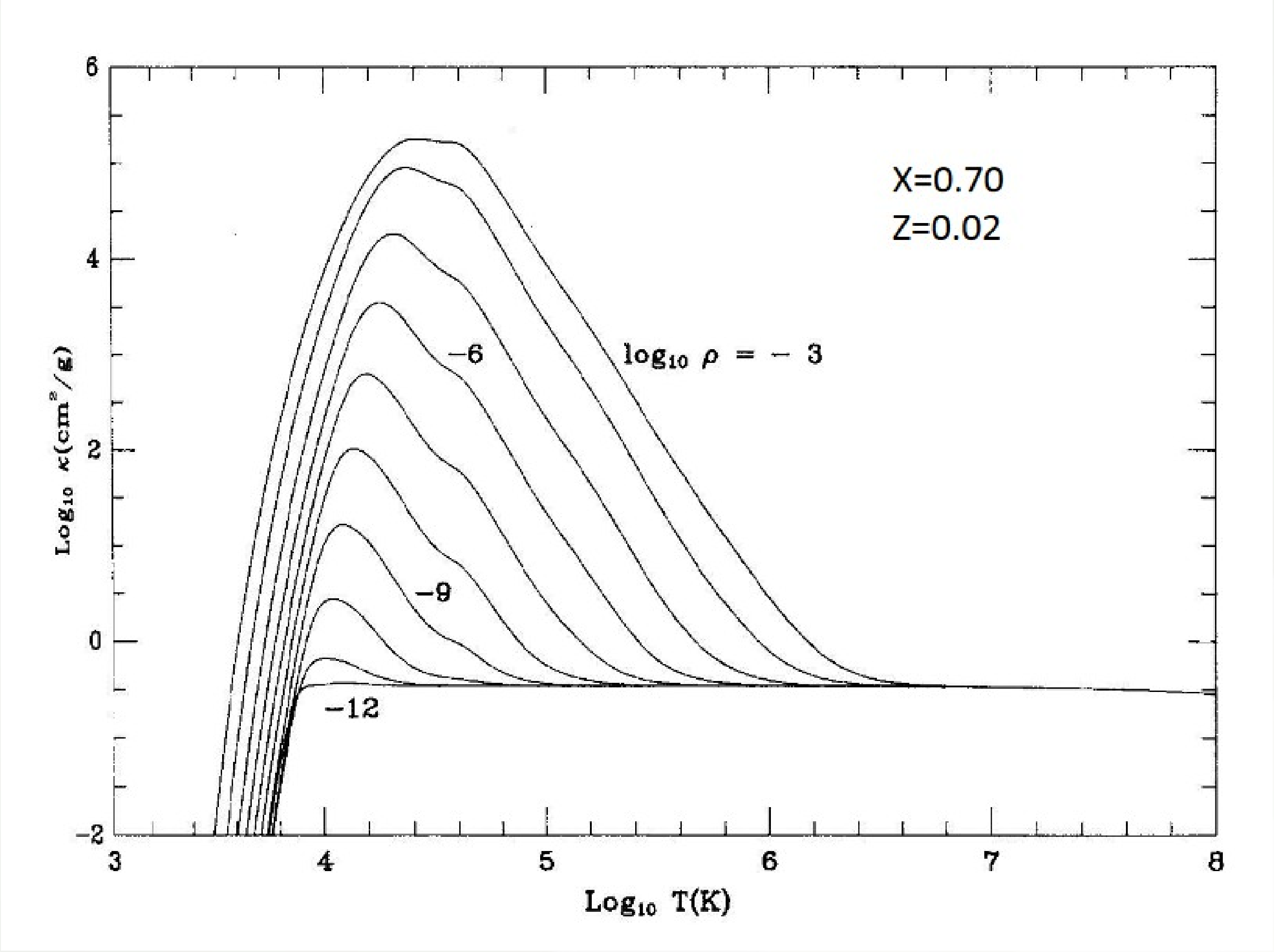
$$A = \frac{(7-n)(a+1)-4-a+b}{0.5(3-n)(a+1)-1}$$

$$\kappa = \kappa_0 \rho^a T^b$$

$$B = -\frac{(n-1)(a+1)+1}{0.5(3-n)(a+1)-1}$$

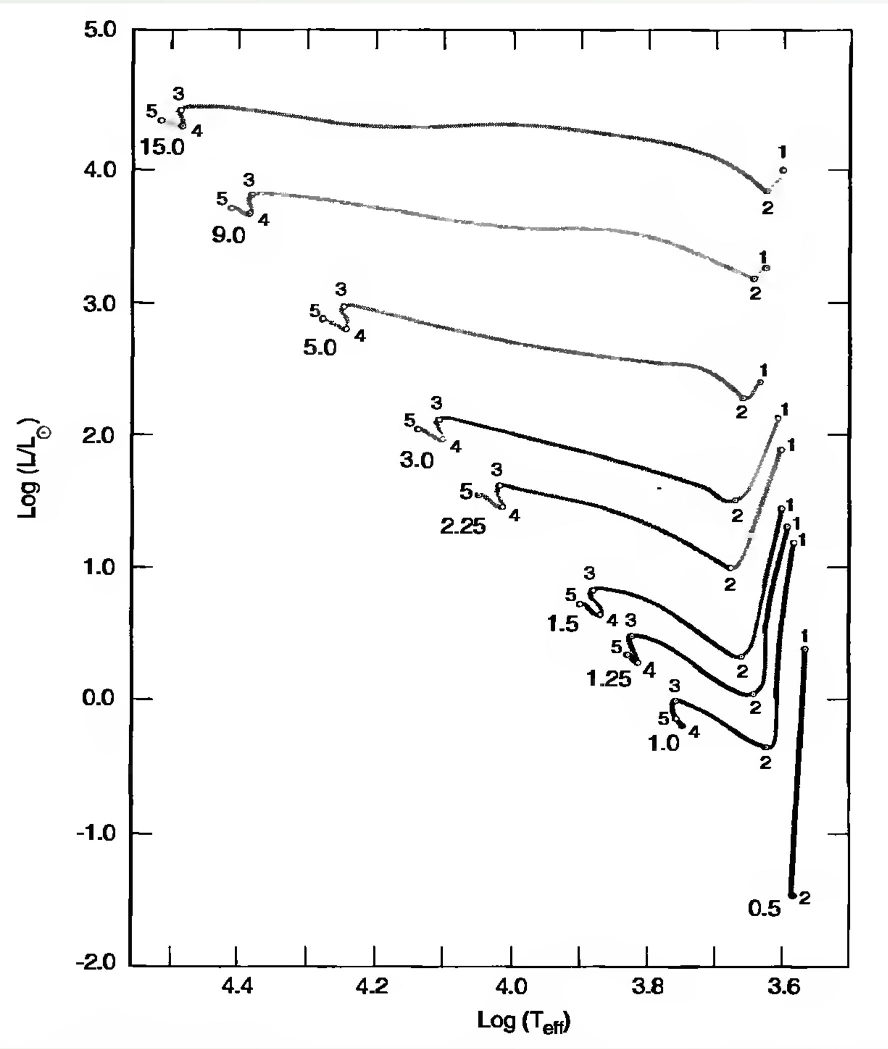


1. vertikalna črta za nizke T
2. pomik v levo za večje M
3. naklon odvisen od mase



Iglesias & Rogers (1996)

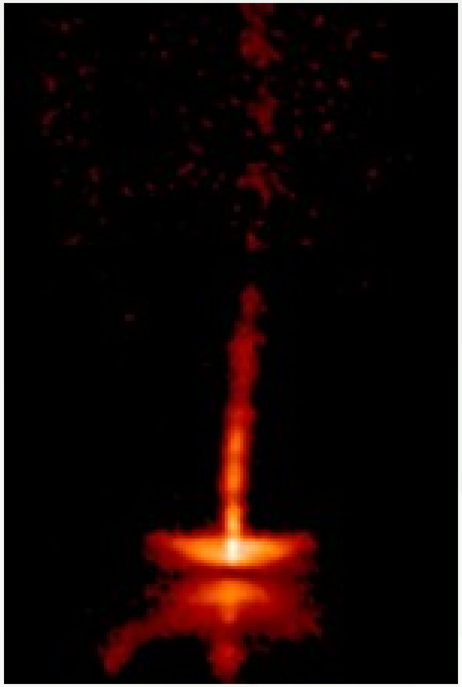
razvoj zvezd (leta) za različne mase zvezd



$M/M_\odot$	*1–2*	*2–3*	*3–4*	*4–5*
15	6.7(2)	2.6(4)	1.3(4)	6.0(3)
9	1.4(3)	7.8(4)	2.3(4)	1.8(4)
5	2.9(4)	2.8(5)	7.4(4)	6.8(4)
3	2.1(5)	1.0(6)	2.2(5)	2.8(5)
2.25	5.9(5)	2.2(6)	5.0(5)	6.7(5)
1.5	2.4(6)	6.3(6)	1.8(6)	3.0(6)
1.25	4.0(6)	1.0(7)	3.5(6)	1.0(7)
1.0	8.9(6)	1.6(7)	8.9(6)	1.6(7)
0.5	1.6(8)			

Note: powers of 10 are given in parentheses.

Zvezde T-Tauri



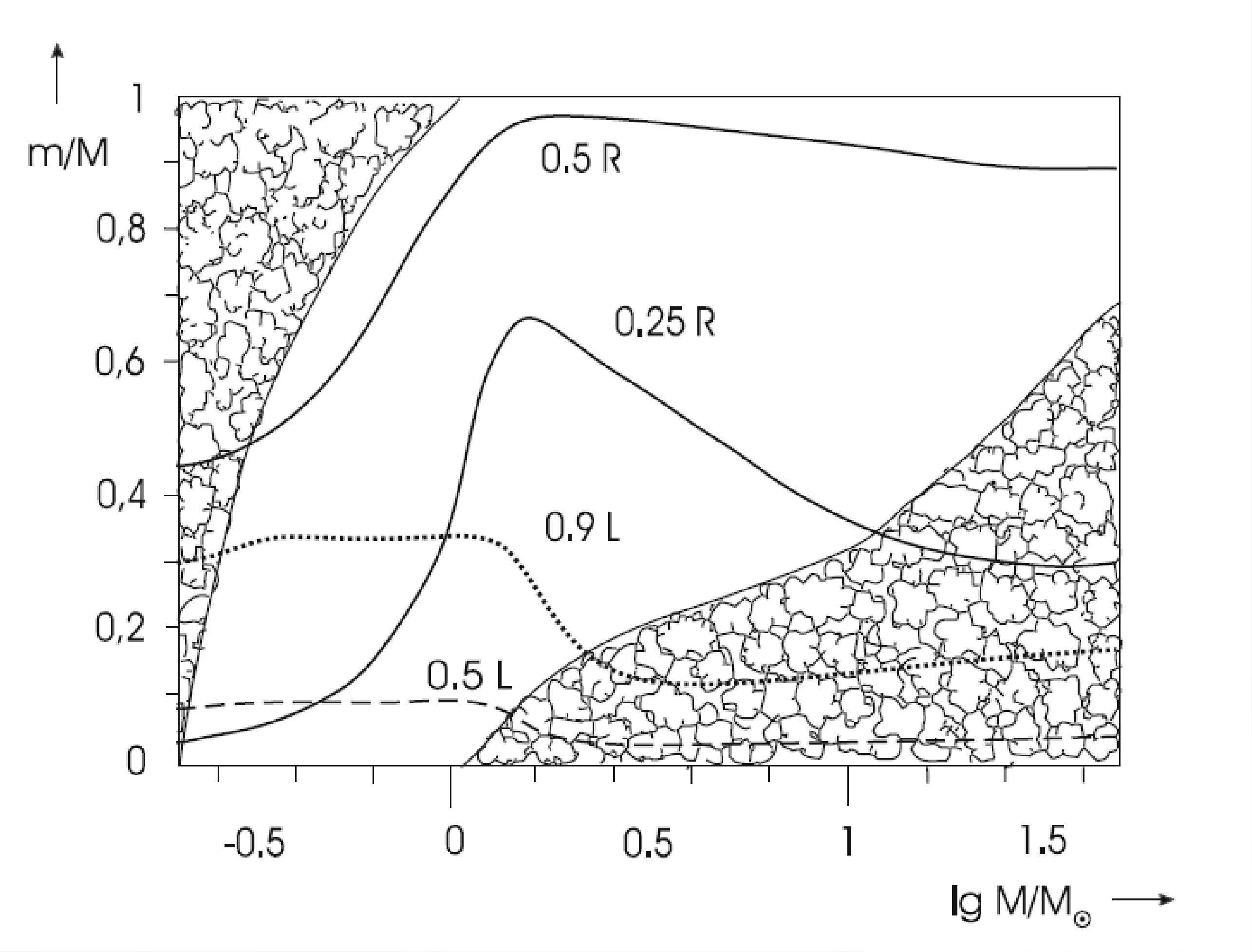
The T Tauri star HH-30 shows ‘bullets’ of material propagating along a jet. *Credit: NASA, A. Watson (UNAM), K. Stapelfeldt (JPL), J. Krist (STScI) and C. Burrows (ESA/ STScI)*

- 1945 – razred zvezd tipa T Tauri
- aktivne in spremenljive mlade zvezde
- $M < 3M_{sun}$, starost < 10 milijonov let
- nizke T_c (ni izgorevanja vodika)
- energija zaradi gravitacijskega krčenja
- do glavne veje v 100 milijonih let
- polovica jih ima protoplanetarni disk

→ *vmesna faza med protozvezdo in zvezdo glavne veje*

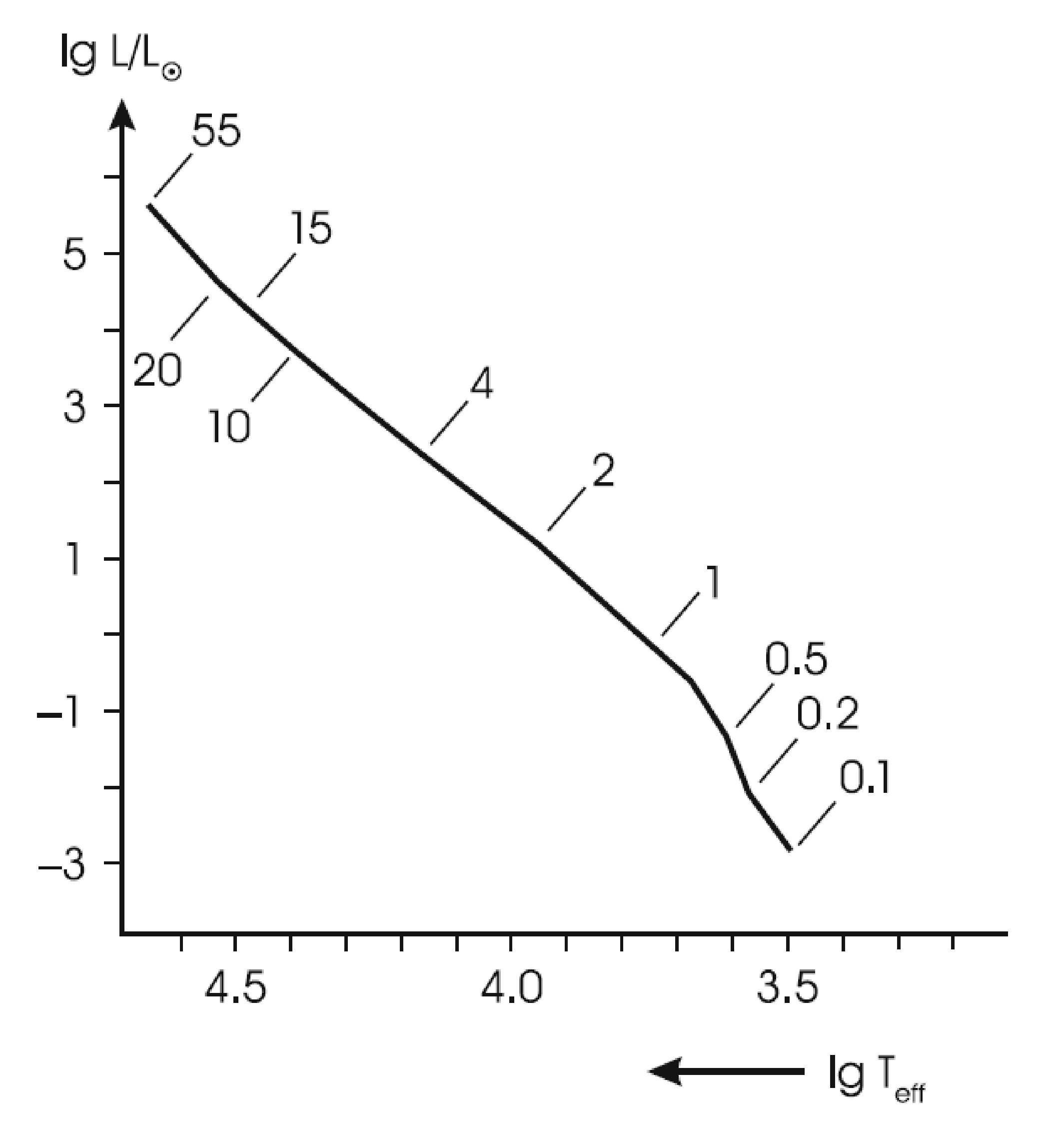
Slika zgoraj: NGC 1555, refleksijska meglica, ki jo osvetljuje zvezda T Tauri (v ozvezdju Bika).
Avtorstvo: Adam Block/Mount Lemmon SkyCenter/University of Arizona - http://www.caelumobservatory.com/gallery/n1555.shtml

Konvekcija v zvezdah glavne veje



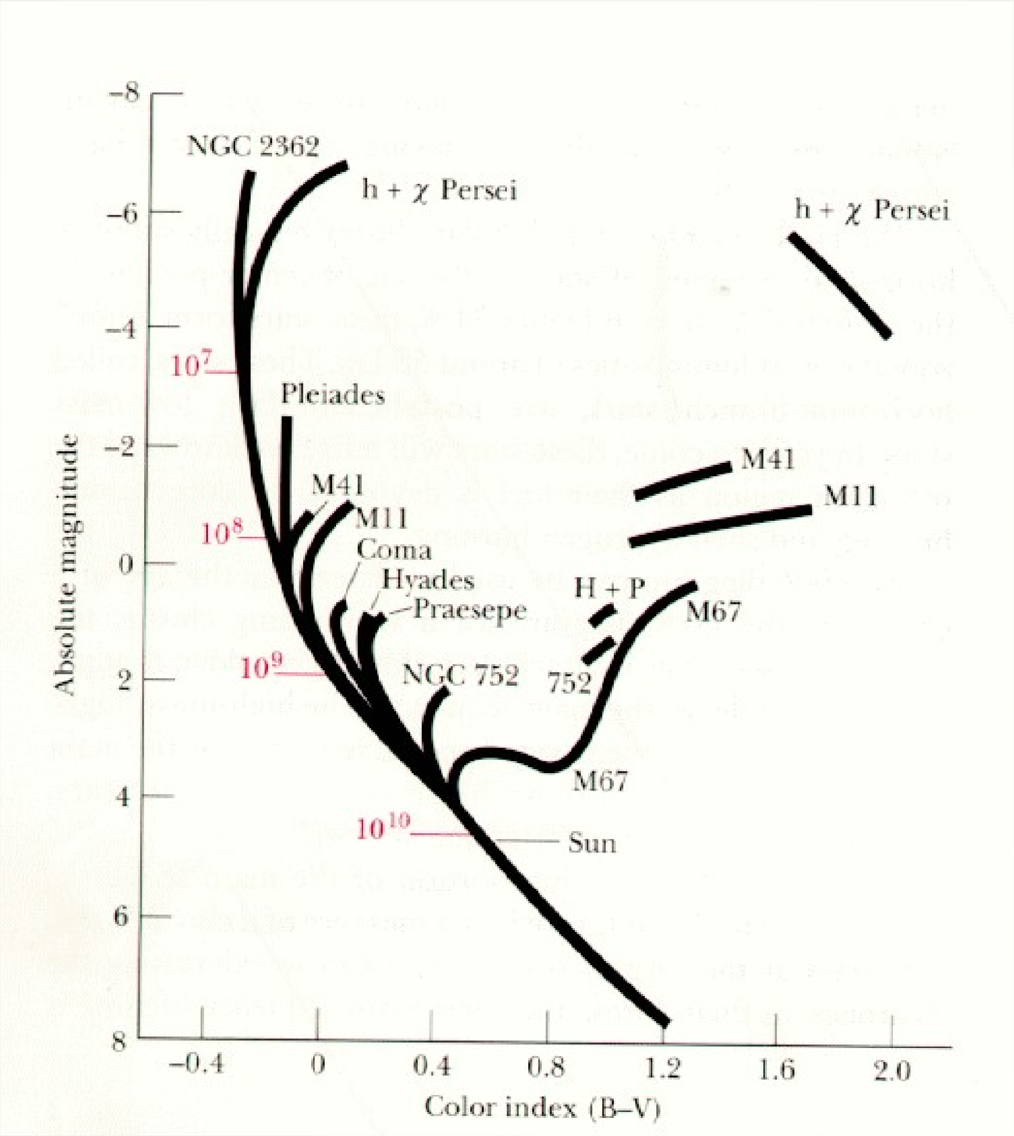
The mass values m from centre to surface are plotted against the stellar mass M for the same zero-age main-sequence model. "Cloudy" areas indicate the extension of convective zones inside the models. Two *solid lines* give the m values at which r is 1/4 and 1/2 the total radius R: The *dashed and dotted lines* show the mass elements inside which 50% and 90% of the total luminosity L are produced

Zero-age main sequence



Hertzsprung–Russell diagram with the zero-age main sequence computed for a composition with $X_H = 0.70$; $X_{He} = 0.28$. The locations of models for several masses between 0.1 and 55 Msun are indicated.

Glavna veja in zvezdne kopice



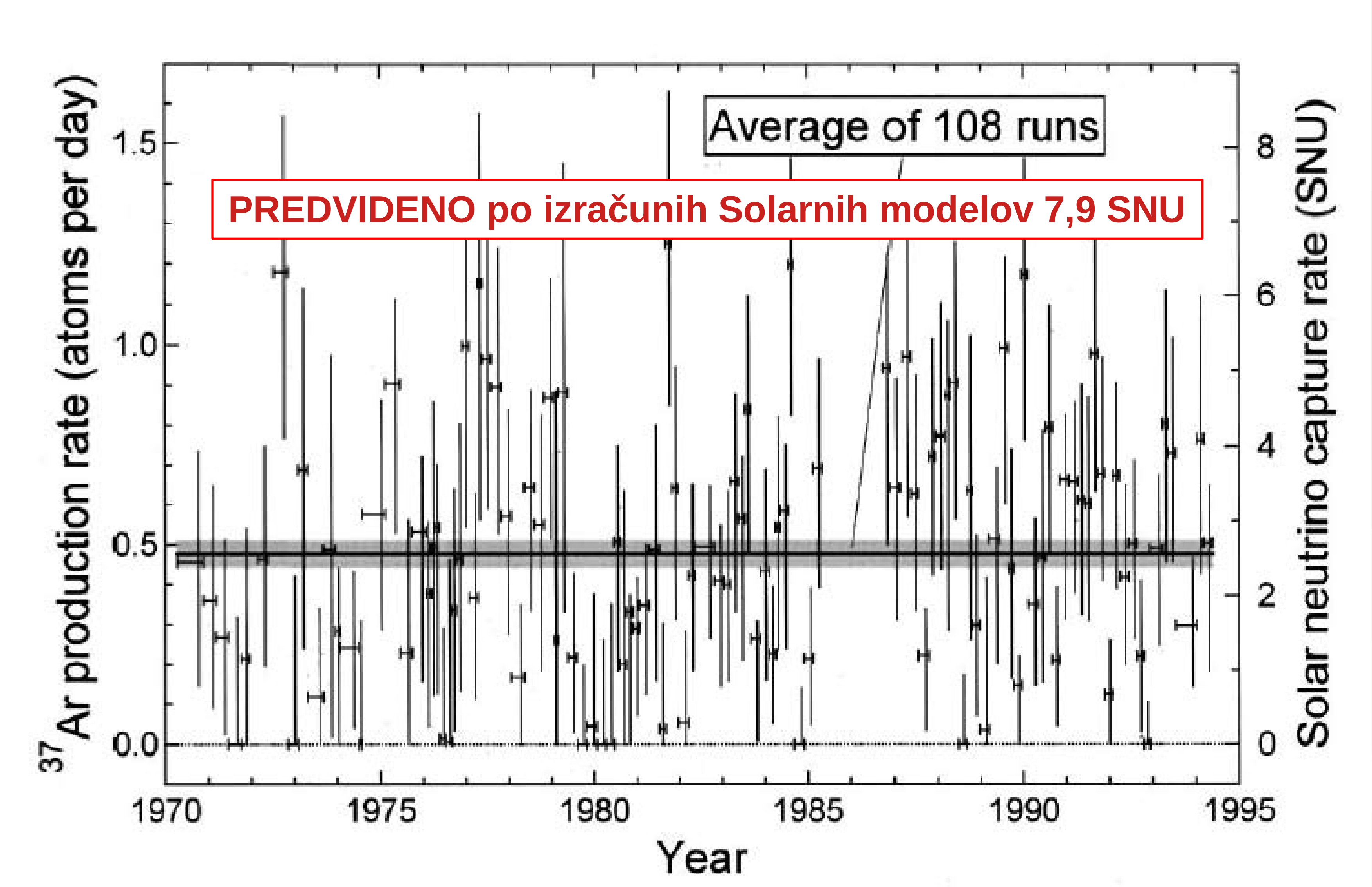
Solarni nevtrini

Rudnik zlata Homestake (Južna Dakota) in eksperiment meritve nevtrinov iz Sonca

- 1967 – Raymond Davis, teoretični izračuni John Bahcall
- nevtrini s Sonca

Težava:
- nizek sipalni presek nevtrinov
- moteči kozmični delci

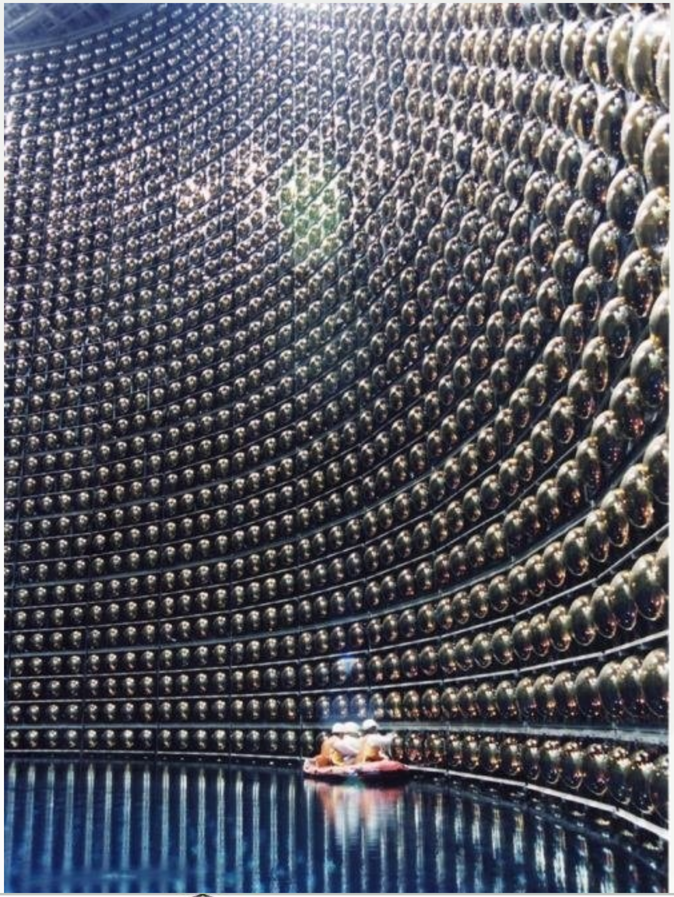
Detektor:
- 1500 m pod zemljo
- 380 m3 tetrakloretilena C_2Cl_4



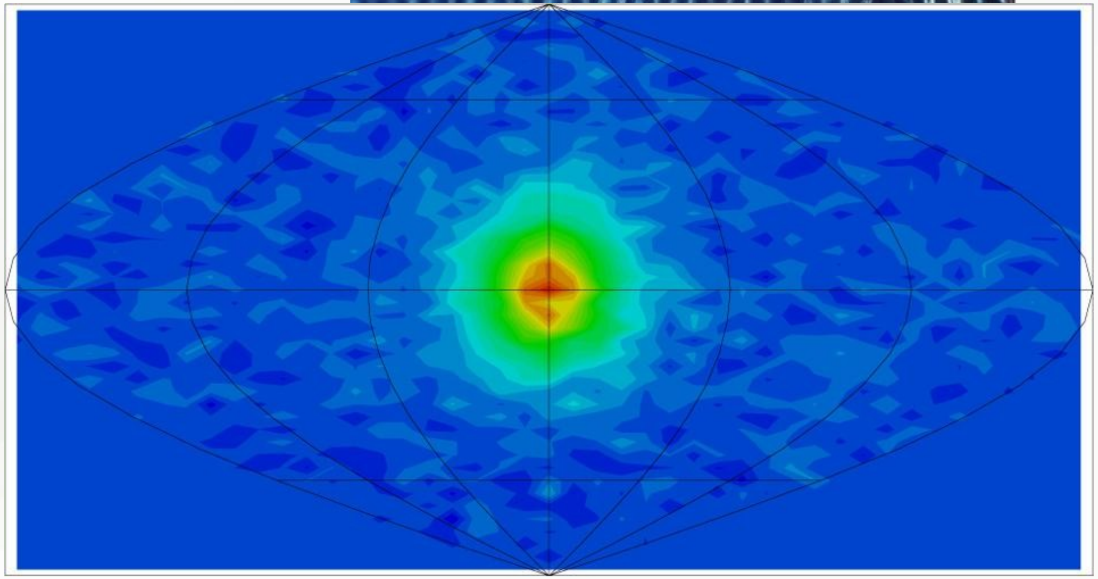
Measured solar neutrino capture rate in Ray Davis' chlorine experiment at Homestake between 1970 and 1995. The observed average solar neutrino flux was 2.56±0.16±0.16 SNU, about a third of the current solar model prediction of 7.6+1.3−1.1 SNU. The neutrino capture rate is given in Solar Neutrino Units (SNU). One SNU is equivalent to $10^{-36}s^{-1}$ interactions per nucleus.

SuperKamiokande

- rudnik Kamioka Mozumi (Japonska)
- 2700m pod zemljo
- posoda: 40m premera, 40m globine
- 50 000 m^3 vode
- sipanje nevtrinov in elektronov



$$\nu + e^- \rightarrow \nu' + e^{-\prime}$$



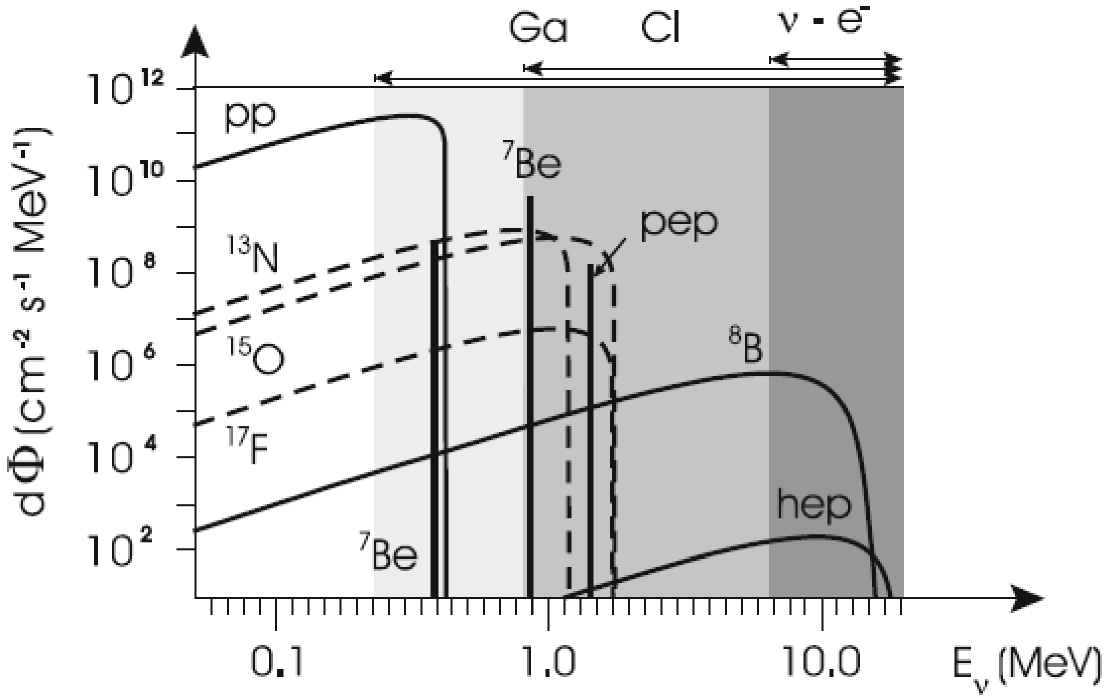


Fig. 29.7. The neutrino spectrum of the Sun as predicted from the theoretical standard solar model. The *solid lines* belong to reactions of the *pp* chain while the *broken lines* are due to reactions of the CNO cycle. The neutrinos from most of the reactions have continuous spectra, while monoenergetic neutrinos come from ^{7}Be and from the *pep*-reaction (29.1). The flux ϕ for the continuum sources is given in $cm^{-2}\,s^{-1}\,MeV^{-1}$ and for the line sources in $cm^{-2}\,s^{-1}$. The sensitivity of the three types of neutrino experiments is indicated above the figure and by the *shaded* regions

SNO Sudbury Neutrino Observatory