Corot HH3, model star 1

HD 45067

$T_{eff} = 6050 \pm 100$ K $\qquad 3.15 \leq M_{bol} \leq 3.4$

[Fe/H] $= -0.17 \pm 0.1$ $\qquad V \sin i = 6 \pm 4$ km/s.

Conversion of M_{bol} into physical units (erg s^{-1})

$M_{bol,\odot} = 4.75 \qquad L_\odot = 3.844 \times 10^{33}$.

Conversion of [Fe/H] into Z/X

[Fe/H] $\simeq$ [Z/X] with unknown error $\qquad \mathrm{Z/X} = (\mathrm{Z/X})_\odot \times 10^{[\mathrm{Z/X}]}$

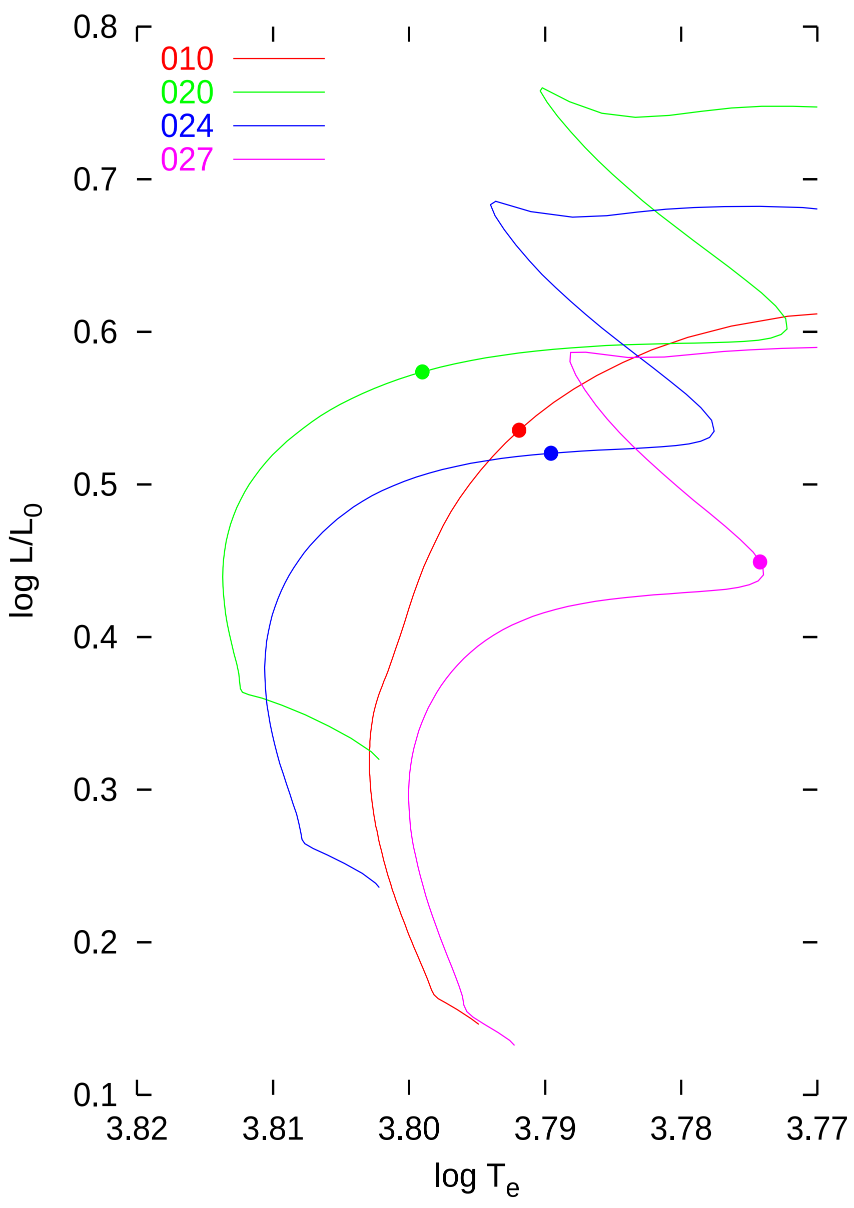
$(\mathrm{Z/X})_\odot = 0.0245$ with at least a ten percent uncertainty.

$0.0146 \leq \mathrm{Z/X} \leq 0.0186$

Input parameter ranges (E. Michel) $\longrightarrow$ Frequencies production (M.J. Goupil) $\longrightarrow$ Time series production (T. Appourchaux) $\longrightarrow$ Time series analysis (R.A. Garcia, C. Barban) $\longrightarrow$ seismic interpretation.

Evolutionary paths go through the box in the HR diagram at different stages of evolution.

	010	020	024	027
M	1.080	1.230	1.150	1.090
X_0	0.70	0.70	0.71	0.71
Z_0	0.00115	0.015	0.0115	0.0115
α	1.8	1.7	1.8	1.8
α_{ov}	0	0.2	0.2	0.2
diff	no	no	no	no



Seismic modelling: the method

- Compute sequences with different choices of M, X_0, Z_0, α (mixing-length parameter), α_{ov} (overshooting parameter), with/without diffusion ;
- on each sequence select the *best* model, which optimizes the fit in the $\Delta\nu$ and $\delta\nu$ space ;

$$\begin{aligned}
\Delta\nu_{l,n} &= \nu_{l,n} - \nu_{l,n-1} \\
\delta\nu_{l,n} &= \nu_{l,n} - \nu_{l+2,n-1} \\
\delta'\nu_{l,n} &= 2\nu_{l,n} - \nu_{l+1,n} - \nu_{l+1,n-1}
\end{aligned}$$

- accept or reject, try to improve.

The best fits were obtained for models on the end of the main sequence before or just at the beginning of the second gravitational contraction.

For models with overshooting, $\delta'\nu$ as function of ν shows a slope incompatible with the observations. The given model star has no overshooting or the overshooting parameter is clearly lower than generally admitted values.

Good fits can be obtained for parameters in the following ranges

$1.14 \leq M/M_\odot \leq 1.40$

$0.66 \leq X_0 \leq 0.72$

$0.0115 \leq Z_0 \leq 0.019$

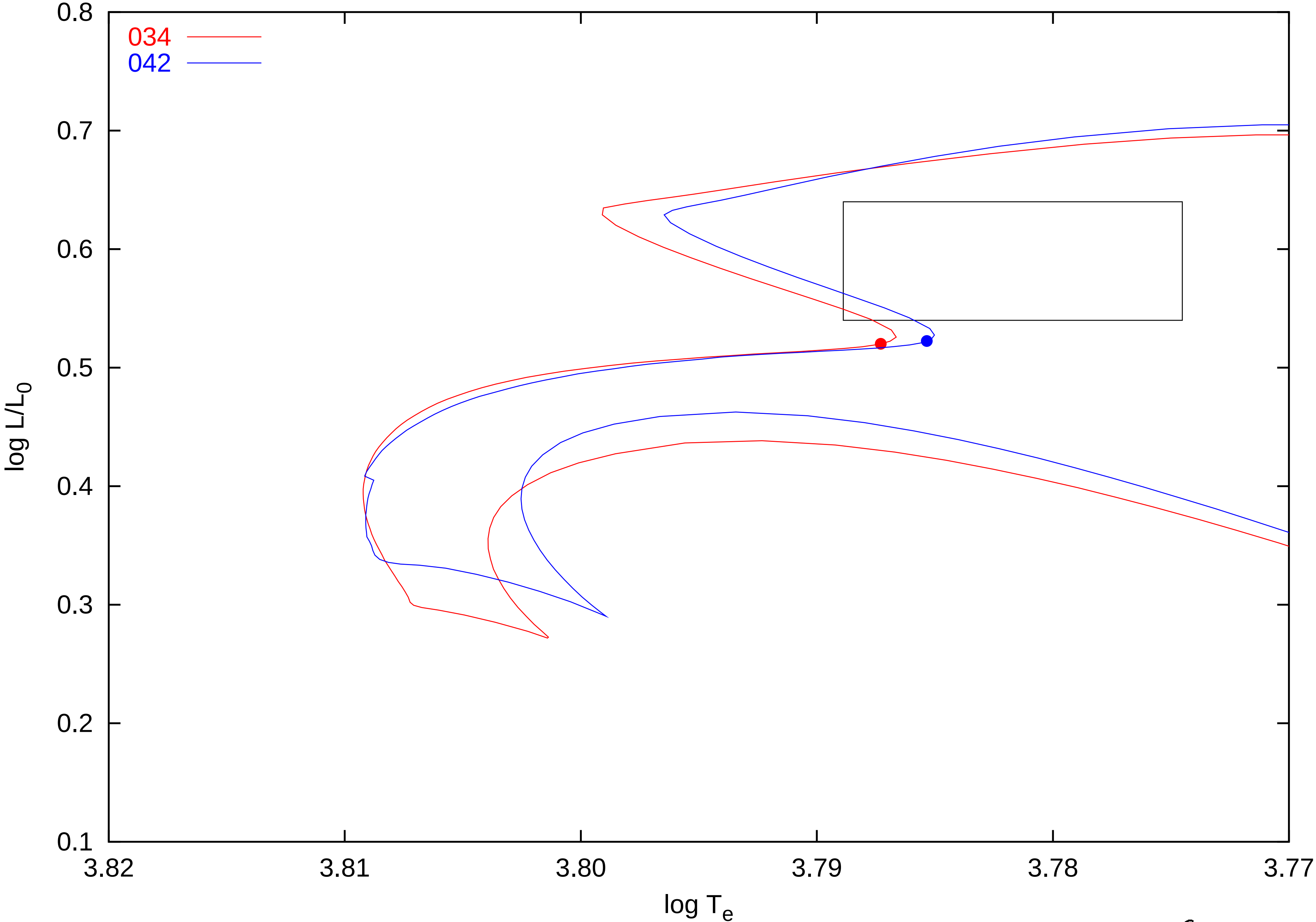
$1.7 \leq \alpha \leq 1.8$

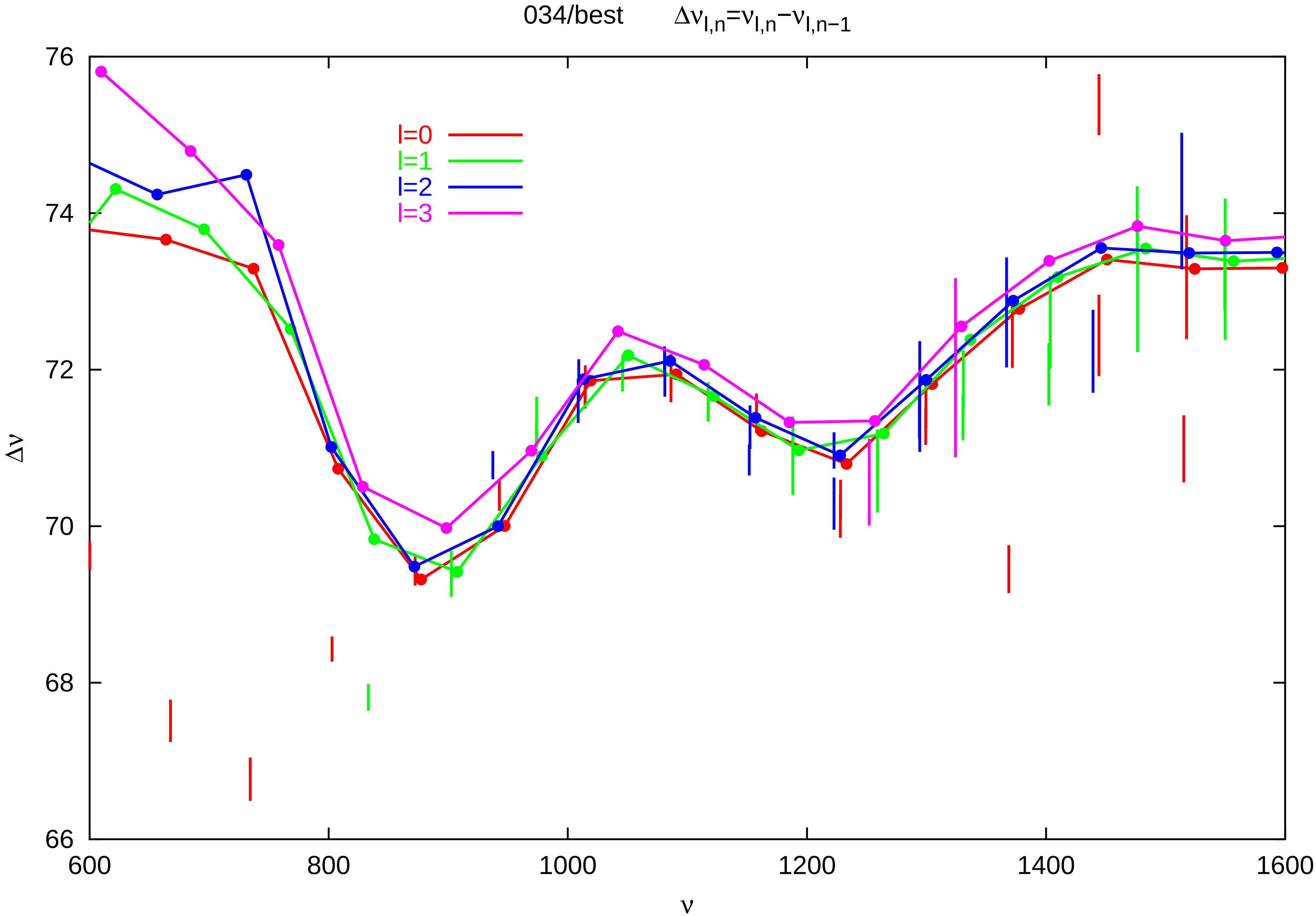
No overshooting or $\alpha_{ov} \ll 0.2$

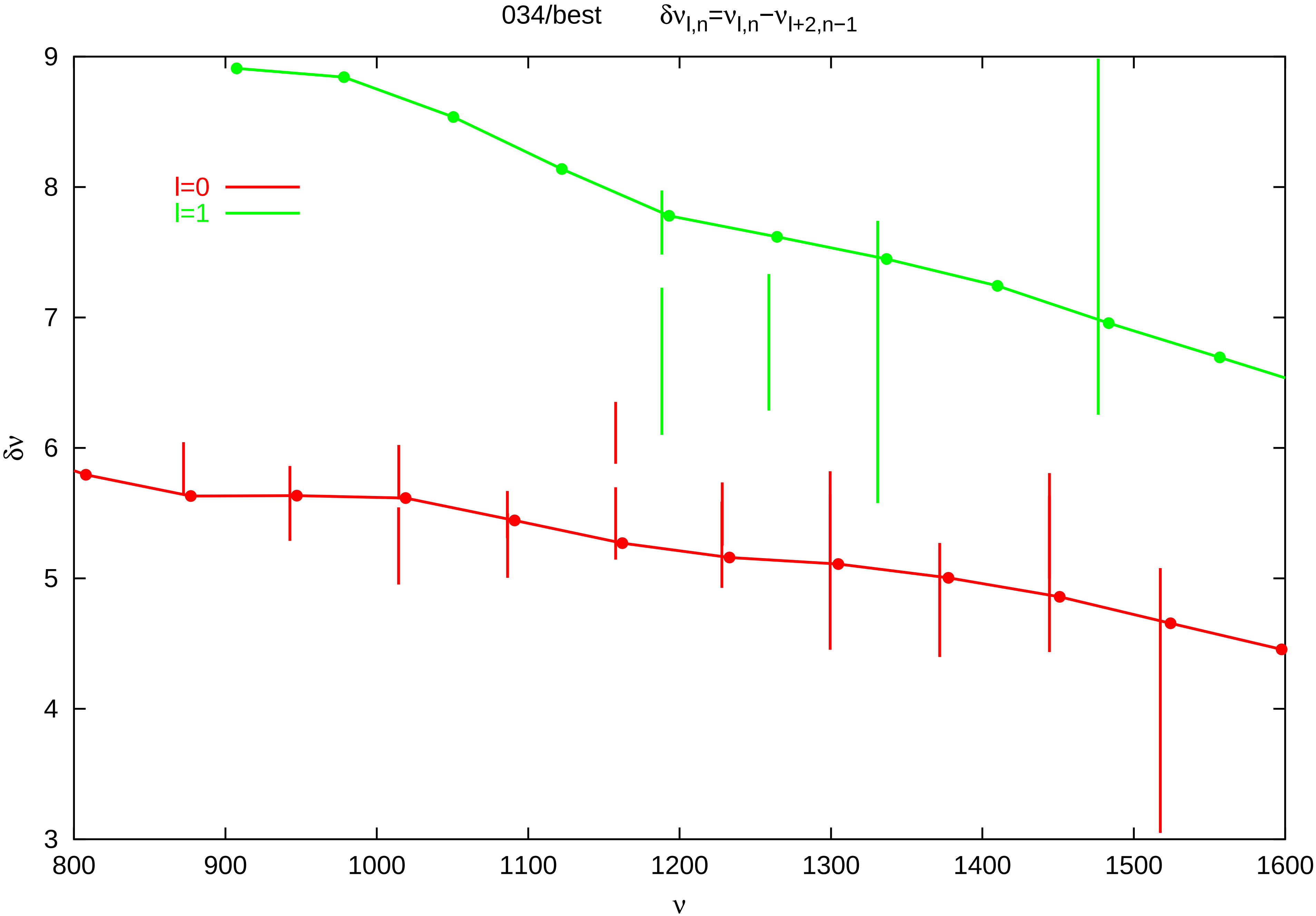
with/without diffusion

We illustrate with two rather different models

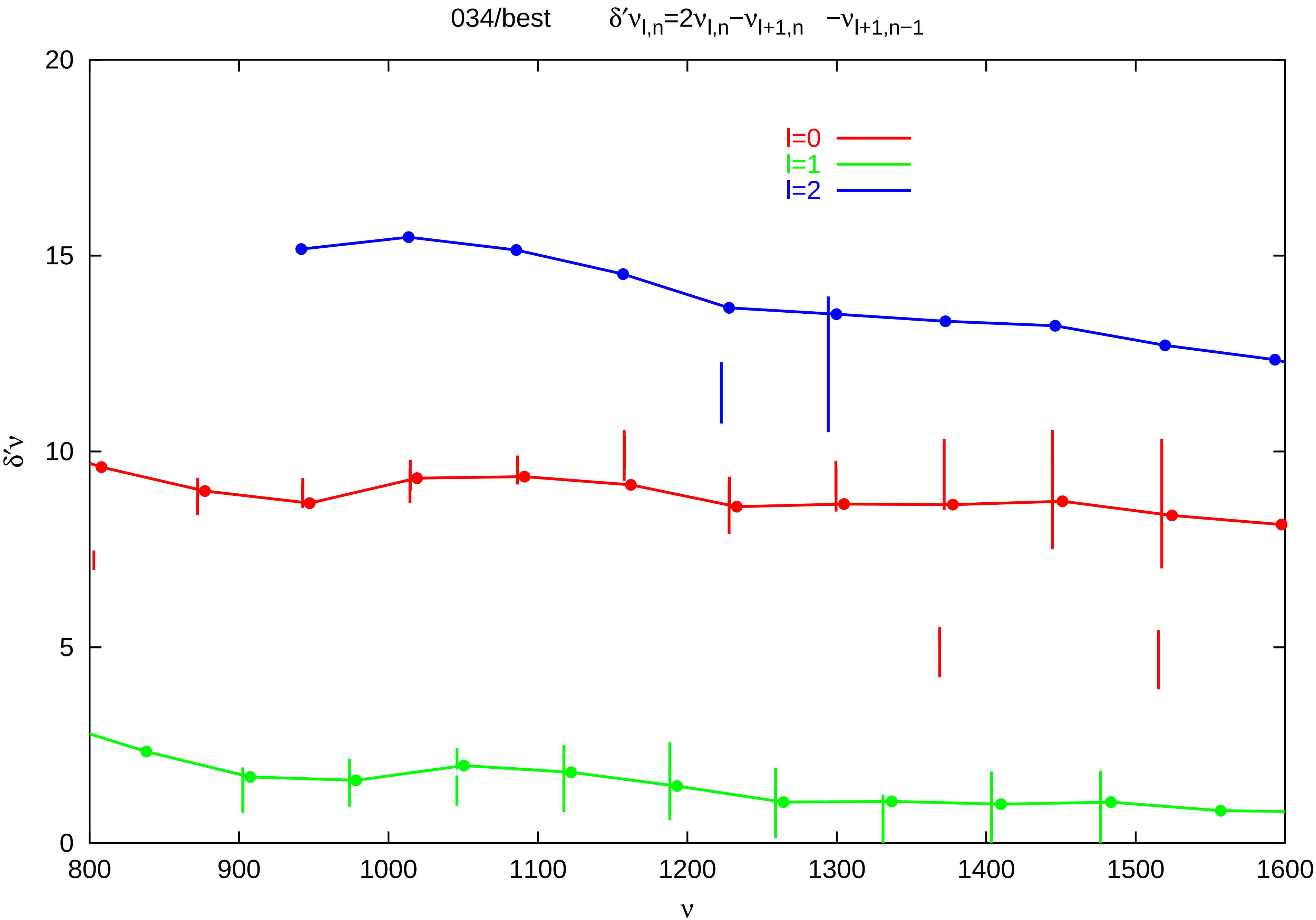
Best model of sequence 34	Best model of sequence 42
$M/M_\odot = 1.188$	$M/M_\odot = 1.225$
$X_0 = 0.72$	$X_0 = 0.69$
$Z_0 = 0.012$	$Z_0 = 0.018$
$\alpha = 1.7$	$\alpha = 1.8$
$\alpha_{ov} = 0.05$	no overshooting
reduced diffusion (0.25)	with diffusion
age $= 4.37$ Gyr	age $= 3.77$ Gyr
$\log T_{eff} = 3.7873$	$\log T_{eff} = 3.7853$
$\log L/L_\odot = 0.5202$	$\log L/L_\odot = 0.5225$
$(Z/X)_{surf} = 0.0148$	$(Z/X)_{surf} = 0.0174$

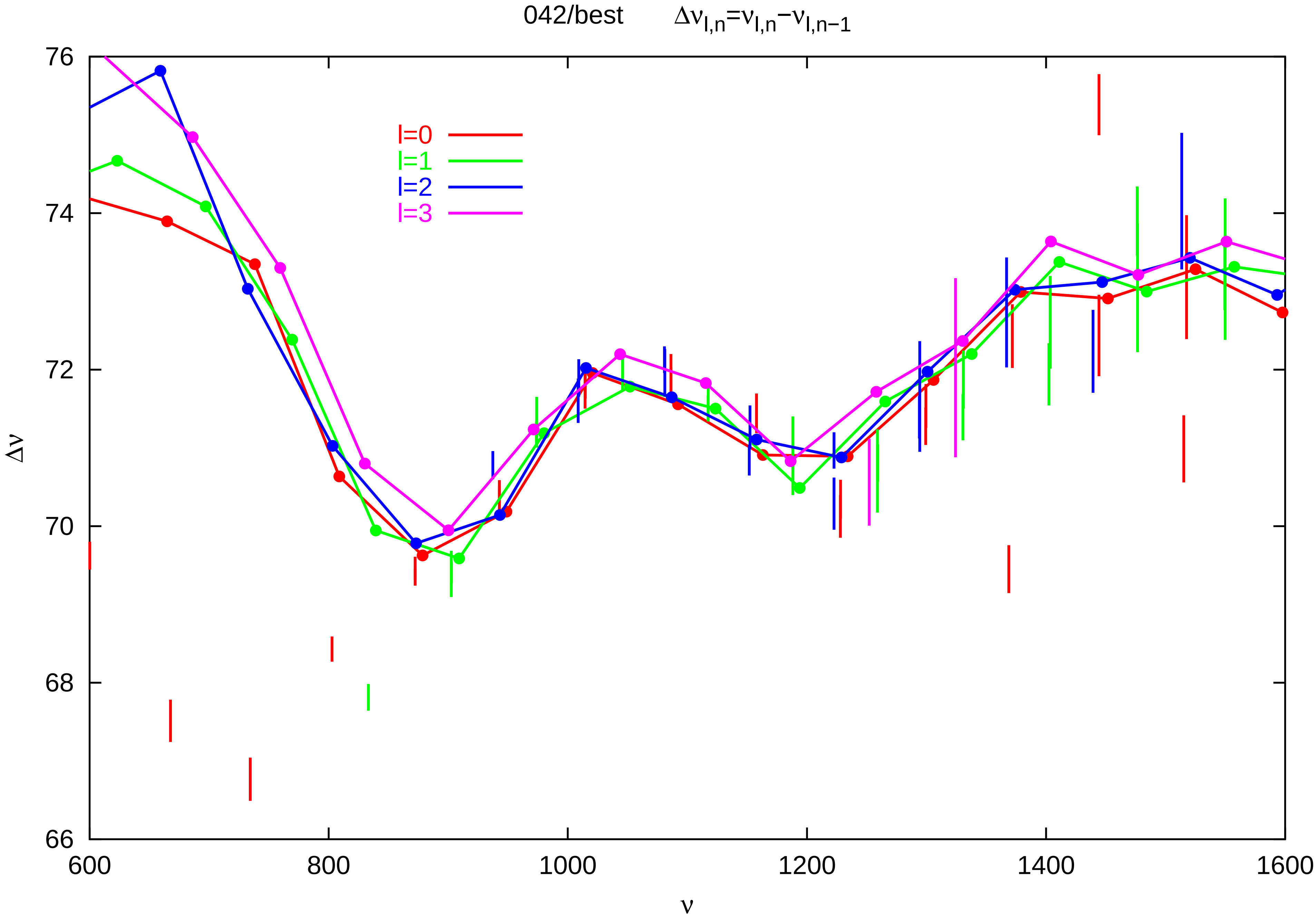

034
042
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
3.82
3.81
3.80
3.79
3.78
3.77
log L/L0
log Te

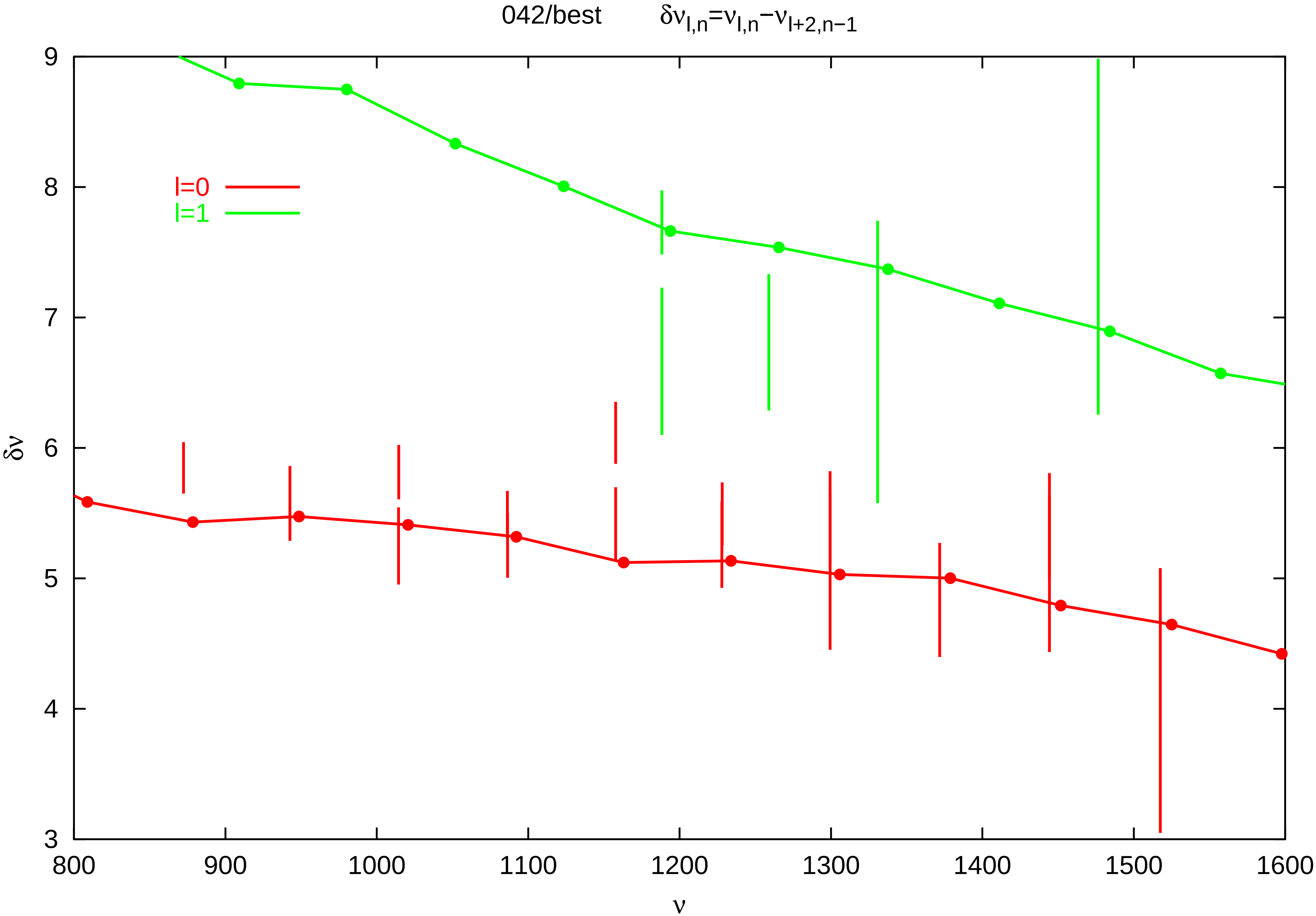

034/best
$\Delta\nu_{l,n}=\nu_{l,n}-\nu_{l,n-1}$
l=0
l=1
l=2
l=3
76
74
72
70
68
66
600
800
1000
1200
1400
1600
$\Delta\nu$
ν

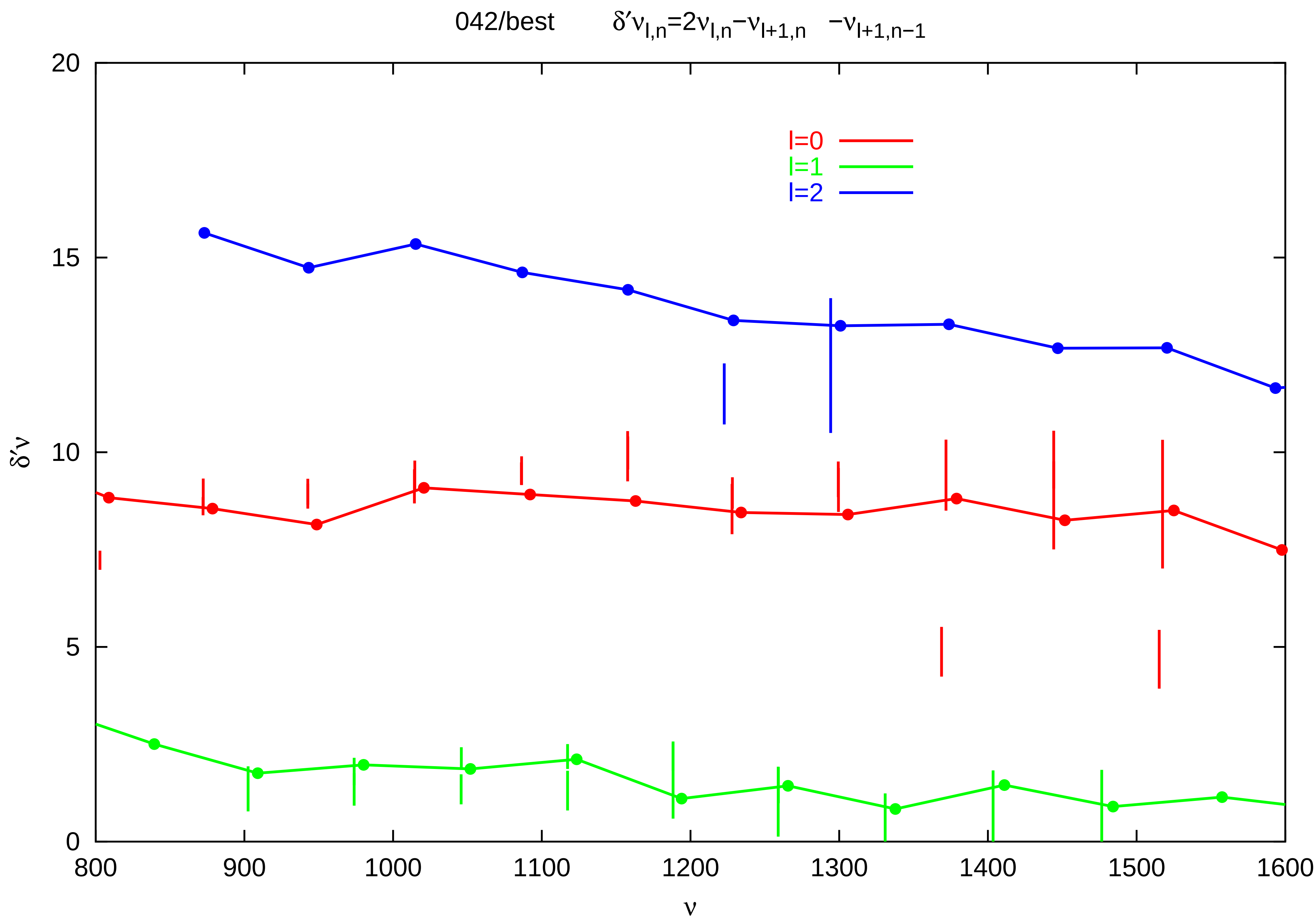


034/best δν$_{l,n}$=ν$_{l,n}$−ν$_{l+2,n-1}$
l=0
l=1
9
8
7
6
5
4
3
δν
800
900
1000
1100
1200
1300
1400
1500
1600
ν


034/best δ′ν_{l,n}=2ν_{l,n}−ν_{l+1,n} −ν_{l+1,n−1}
l=0
l=1
l=2
δ′ν
ν
20
15
10
5
0
800
900
1000
1100
1200
1300
1400
1500
1600


042/best
$\Delta\nu_{l,n}=\nu_{l,n}-\nu_{l,n-1}$
l=0
l=1
l=2
l=3
76
74
72
70
68
66
600
800
1000
1200
1400
1600
Δν
ν


042/best
δν_{l,n}=ν_{l,n}−ν_{l+2,n−1}
l=0
l=1
δν
ν
9
8
7
6
5
4
3
800
900
1000
1100
1200
1300
1400
1500
1600


042/best δ′ν_{l,n}=2ν_{l,n}−ν_{l+1,n} −ν_{l+1,n−1}
l=0
l=1
l=2
δ′ν
ν
0
5
10
15
20
800
900
1000
1100
1200
1300
1400
1500
1600

Best model of sequence 034

$M/M_\odot = 1.188$
$X_0 = 0.72$
$Z_0 = 0.012$
$\alpha = 1.7$
$\alpha_{ov} = 0.05$
reduced diffusion (0.25)
age= 4.37 Gyr
$\log T_{eff} = 3.7873$
$\log L/L_\odot = 0.5200$
$X_c = 0.05886$
$(Z/X)_{surf} = 0.0148$
$R = 1.1258310 \times 10^{11}$ cm
convective core without overshooting extension: $r_c/R = 0.051619$, $m_c/M = 0.063324$
convective core with overshooting extension: $r_m/R = 0.053413$, $m_m/M = 0.068938$

Frequencies in μHz

mode	$\ell = 0$	$\ell = 1$	$\ell = 2$	$\ell = 3$
3			4.33914112E+02	4.58793445E+02
4		4.10804803E+02	5.07650984E+02	5.33904814E+02
5	4.44251995E+02	4.74757867E+02	5.82425774E+02	6.09721557E+02
6	5.16457519E+02	5.47616157E+02	6.56676100E+02	6.84521244E+02
7	5.90273764E+02	6.21931711E+02	6.95765321E+02	7.58120403E+02
8	6.63941630E+02	6.95732673E+02	7.31143822E+02	8.28637740E+02
9	7.37240676E+02	7.68258899E+02	8.02180861E+02	8.52862299E+02
10	8.07975825E+02	8.38095896E+02	8.71672168E+02	8.98608474E+02
11	8.77304236E+02	9.07520376E+02	9.41678085E+02	9.69583104E+02
12	9.47312787E+02	9.78426242E+02	1.01356690E+03	1.04208026E+03
13	1.01918232E+03	1.05061635E+03	1.08568060E+03	1.11414288E+03
14	1.09112358E+03	1.12228162E+03	1.15707292E+03	1.18547493E+03
15	1.16234258E+03	1.19325398E+03	1.22797894E+03	1.25682379E+03
16	1.23313785E+03	1.26444212E+03	1.29985709E+03	1.32938460E+03
17	1.30496497E+03	1.33683142E+03	1.37273994E+03	1.40277876E+03
18	1.37774269E+03	1.41002185E+03	1.44630431E+03	1.47661810E+03
19	1.45115987E+03	1.48357316E+03	1.51979295E+03	1.55026921E+03
20	1.52444529E+03	1.55696361E+03	1.59330131E+03	1.62399047E+03
21	1.59775380E+03	1.63041468E+03	1.66672703E+03	1.69771647E+03
22	1.67095342E+03	1.70393021E+03	1.74051574E+03	
23	1.74451607E+03			

The following figure shows the ratios of $\delta\nu_{n,\ell} = \nu_{n,l} - \nu_{n-1,\ell+2}$ and $\Delta\nu_{n,l} = \nu_{n,\ell} - \nu_{n-1,\ell}$ for $\ell = 0$ and different n.