ON POSSIBLE EXPLANATIONS OF PULSATIONS IN MAIA STARS

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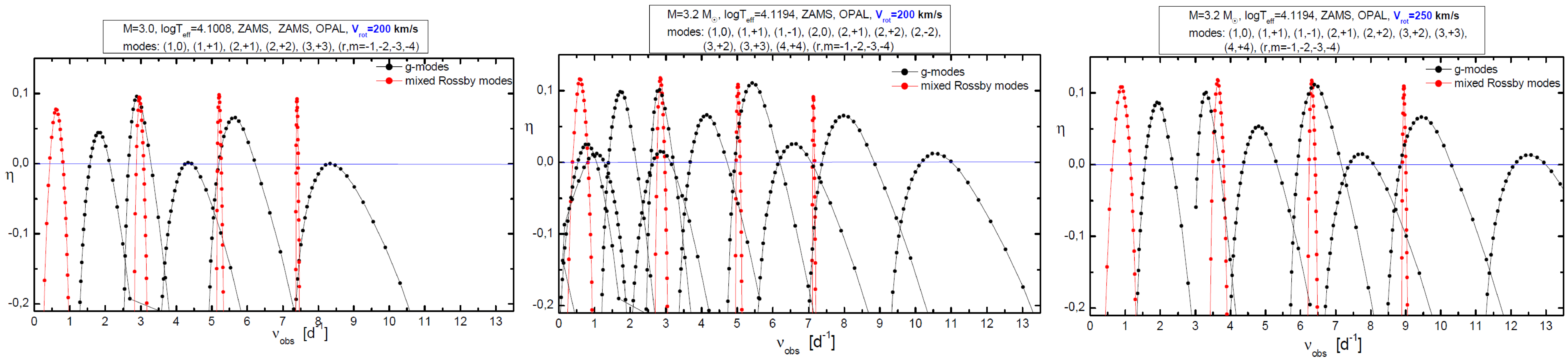
The long-time photometric surveys in a few young open clusters allowed to identify the light variability in stars located between the well defined δ Scuti variables and Slowly Pulsating B-type stars (Mowlavi et al, 2013, 2015). The period of these changes is in the range of about 0.1 - 0.7 [d] corresponding to the frequencies of about 1.4 - 10 [d^{-1}]. Several objects of this type were suggested also from the analysis of the Kepler data (Balona et al. 2015a). Assuming the pulsational origin of this variability, we test a few hypotheses. Because all these open clusters are very young, we consider only the ZAMS models with the metallicity Z=0.015.

THE FIRST HYPOTHESIS:
fast rotating stars with underestimated masses

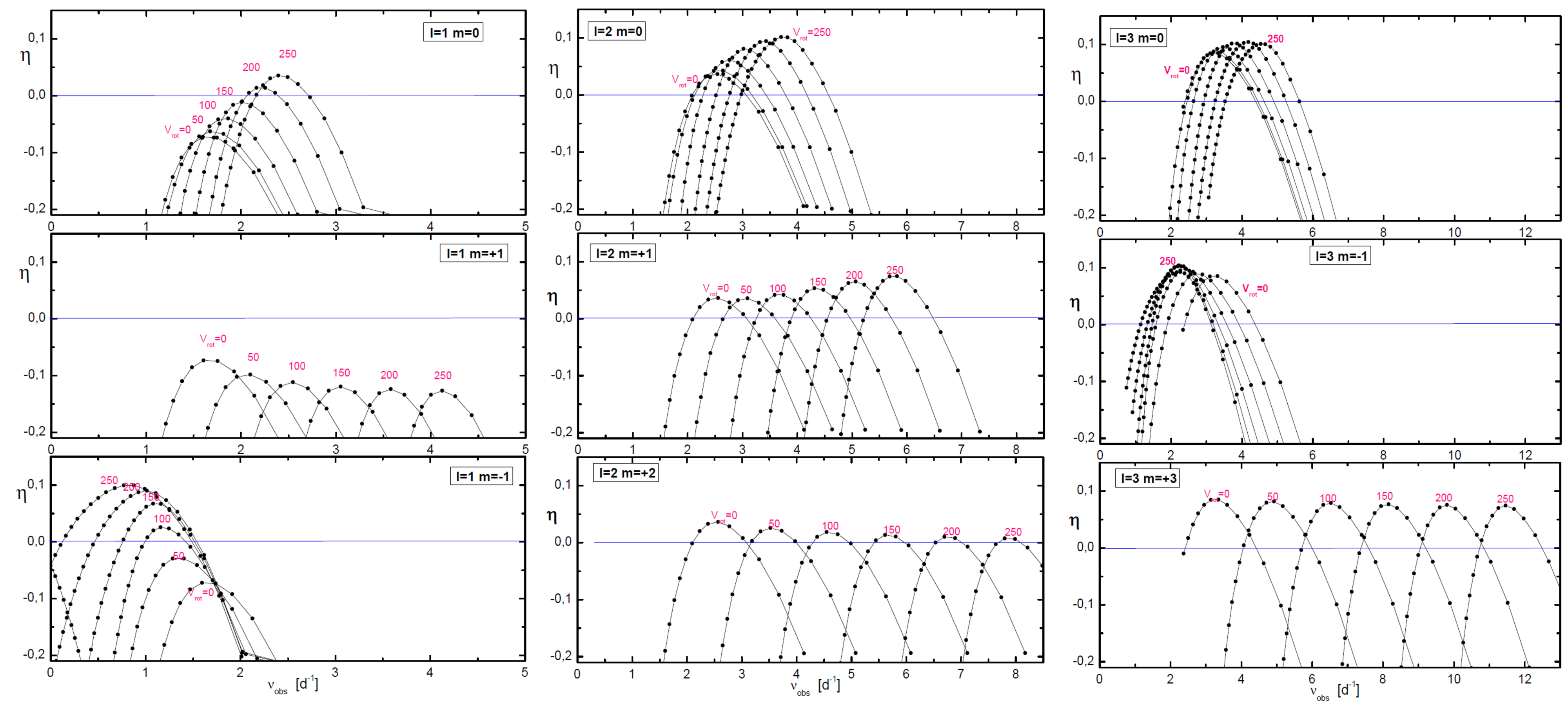
In this case, Maia stars are linked to the Slowly Pulsating B-type stars which rotate very fast. The fast rotation causes that masses of the stars seen close equator-on are underestimated (Salmon et al. 2014). We perform the pulsational computations for models with masses M=3 - 4 $M_\odot$ in the framework of the traditional approximation. High order gravity modes as well as mixed gravity-Rossby modes are considered. In models with masses corresponding to B8-A2 type, these modes are stable. Their instability begins from the mass of about M=3 $M_\odot$. Below we show the instability parameter as a function of frequency for the two masses and the two values of the rotational velocity. Only modes which reach instability are shown.

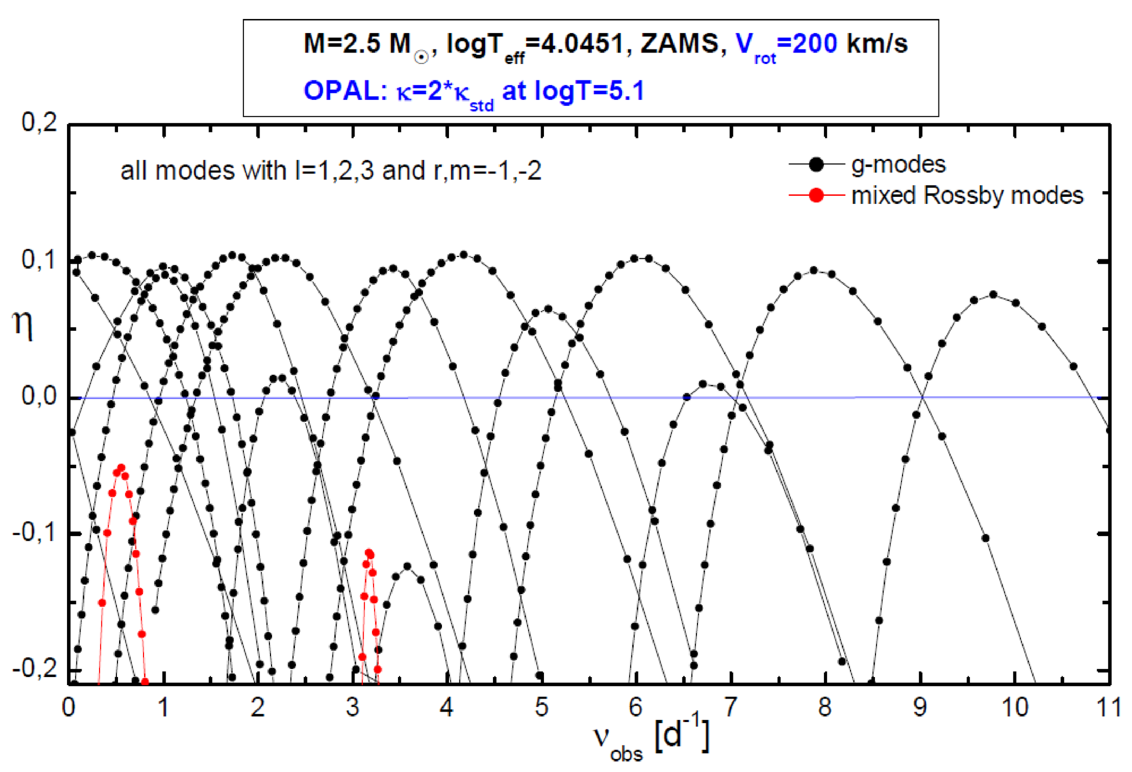


THE SECOND HYPOTHESIS:
fast rotating stars with modified opacities

In the second and new scenario, we modify the opacity profile in the rotating models with a mass M=2.5 $M_\odot$. The standard opacities were increased at the depth log T=5.1. This bump was identified in the Kurucz atmosphere models (Cugier 2014) and was suggested, for example, as a possible cause of excitation of low frequency g-modes in δ Scuti stars as detected in the Kepler data (Balona et al. 2015b). Below, we show the effects of increasing the OPAL opacities at logT=5.1 on the pulsational instability.

M=2.5 $M_\odot$, logT$_{eff}$=4.0451, OPAL: κ=2*κ$_{std}$(logT=5.1)
the effects of rotation on selected modes





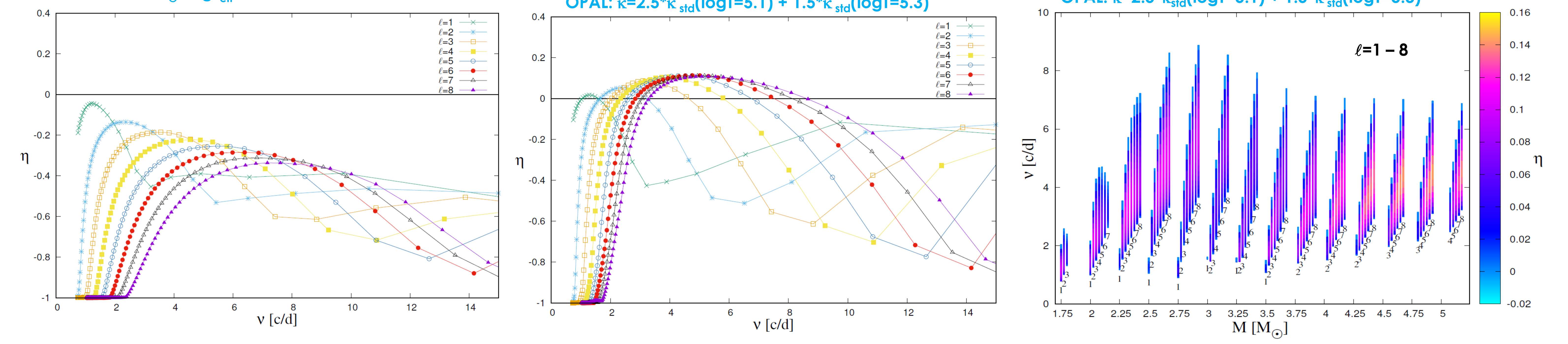
THE THIRD HYPOTHESIS:
slow rotating stars with modified opacities

The third explanation involves modifications of the opacity profile and pulsational modes with the harmonic degrees up to 8. By increasing the mean opacity at the depth logT=5.1 in the M=2.5 model, it is possible to get the instability in the observed frequency range. Adding the second bump at logT= 5.3 makes also the dipole modes unstable. This scenario works for, both, slow and fast rotating stars of B8-A2 type. Below, we show the results for the OPAL data. With the OPLIB and OP data, the results are qualitatively similar.

M=2.5 $M_\odot$, logT$_{eff}$=4.0451, standard OPAL

M=2.5 $M_\odot$, logT$_{eff}$=4.0451
OPAL: κ=2.5*κ$_{std}$(logT=5.1) + 1.5*κ$_{std}$(logT=5.3)

Frequencies of unstable modes vs. mass of the ZAMS models
OPAL: κ=2.5*κ$_{std}$(logT=5.1) + 1.5*κ$_{std}$(logT=5.3)



CONCLUSIONS

Fast rotating stars seen equator-on can account for pulsations of the Maia type. This hypothesis has been already explored by Salmon et al. (2015). The other, new scenarios involve the modification of the opacity profile. We showed that an increase of the opacity at logT≈5.1 is indispensable to get the instability in the frequency range 1.4 – 10 d^{-1}. To decide which scenario is preferred, firstly, more determinations of the rotational velocity of these stars are needed. Then, pulsational analysis of more Maia stars has to be performed taking into account various effects on instability. It cannot be ruled out that rotation and opacity modification can work together.

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