# THEORETICAL MODES FITTING ON MIRAS LIGHT CURVES

D. BARTHÉS
*GRAAL, Université Montpellier II/ CNRS, F-34905 Montpellier Cedex 05, France*

Y. TUCHMAN
*Racah Institute, Hebrew University of Jerusalem, Israel*

M. O. MENNESSIER
*GRAAL, Université Montpellier II/ CNRS, F-34905 Montpellier Cedex 05, France*

and

J. A. MATTEI
*AAVSO, 25 Birch street, Cambridge, MA 02138-1205, USA*

## 1. Observational Data Analysis

Visual observations of long period variable stars over 20 years were provided by the American Association of Variable Stars Observers, and were analysed as part of the preparation of the HIPPARCOS mission.

A set of frequencies is extracted from the light curve by using Fourier transform, preliminary Van Cittert deconvolution and comparison of the results obtained through different kinds of spectral windows. The same procedure is applied to the residual obtained after nonlinear fit of the main frequency. After final comparison of both sets, a nonlinear fit of the common frequencies gives the 'clean' power spectrum.

## 2. Theoretical Model

Different equilibrium stellar model $(i)$ give theoretical linear nonadiabatic pulsation modes $(\nu_j)_i$ with their growth rates $(\eta_j)_i$ (Tuchman 1978). The metallicity is taken between 0.005 and 0.02; the mixing length is $\lambda = 1 \pm 0.2$; the upper bound is $r = 0.7$. Assuming two peaks of the power spectrum to be the fundamental $(\nu_0)$ and first overtone $(\nu_1)$ modes, one looks for the corresponding models. The best one is selected by checking the other theoretical overtones they give. So are obtained the mass, the luminosity, the effective temperature and the effective radius of each star.

## 3. Results

With power spectra of S CMi, R LMi and S UMi one can find a model in excellent agreement not only for fundamental and first overtone modes but also for the next ones. For example, in the case of S CMi (Table I), $\nu_0$, $\nu_1$, $\nu_2$, $\nu_3$ and $\nu_5$ appear in the observed spectrum, while $\nu_4$ (with negative growth

*Astrophysics and Space Science* **210**: 139–140, 1993.

rate) does not. This model gives $L = 7200L_\odot$, $M = 1.9M_\odot$, $T_{\rm eff} = 2155$ K, $R_{\rm eff} = 515R_\odot$.

TABLE I
S CMi

| Observed power spectrum | | Assumption | Model | | | |
|---|---|---|---|---|---|---|
| $\nu(d^{-1})$ | A (mag) | | $\nu$ | $\eta$ | P (days) | |
| 0.00059 | 0.16 | $\nu_0$ | 0.00062 | + | 1610 | $\nu_0$ |
| 0.00132 | 0.17 | | | | | $\nu_3 - \nu_2, \nu_2 - \nu_1, 2\nu_0$ |
| 0.00241 | 0.13 | | | | | $\nu_1 - \nu_0$ |
| 0.00299 | 2.18 | $\nu_1$ | 0.00298 | + | 335 | $\nu_1$ |
| 0.00315 | 0.23 | | | | | $\nu^*$ |
| 0.00422 | 0.15 | | 0.00413 | + | 242 | $\nu_2$ |
| 0.00560 | 0.20 | | 0.00555 | + | 180 | $\nu_3$ |
| 0.00601 | 0.21 | | | | | $2\nu_1$ |
| | | | 0.00680 | − | 147 | |
| 0.00838 | 0.10 | | 0.00833 | + | 120 | $\nu_5, 3\nu_1 - \nu_0$ |
| 0.00896 | 0.23 | | | | | $3\nu_1$ |
| | | | 0.00971 | − | 103 | |
| | | | 0.01075 | + | 93 | |
| 0.01186 | 0.10 | | 0.01190 | + | 84 | $4\nu_1, \nu_8$ |
| | | | 0.01266 | − | 79 | |

In each explained remain a frequency $\nu^*$ and/or its combination with the main one. This can be explained by using a rough atmospheric model: pure $H_2$; $\rho \propto r^{-2}$; $g \propto r^{-2}$; $\gamma = cte$; lower bound at $r = R_{\rm eff}$; $P_{\rm rad}/P = 0.05$. Then $\nu^*$ corresponds to the fundamental radial adiabatic mode of the atmosphere (0.00309 $d^{-1}$ for S CMi).

## 4. Conclusion

- These three miras are pulsating on the *first overtone*;
- Within the physics (convection + surface conditions) used in the theoretical models, one can predict the *masses* and the *luminosities* of Mira variables by using very clear and precise observational parameters (periods of the main modes);
- Only a combination of a stellar model with an atmospheric one can provide a complete interpretation of the power spectrum of the light curve of a Mira star.

## References

Tuchman, Y., Sack, N., and Barkat, Z.: 1978, *Astrophysical Journal* **219** 183.