

## **Observations of red giants in the cluster NGC6633 by the space mission CoRoT and the HARPS and SOPHIE spectrometers**

C. Barban<sup>1</sup>, F. Baudin<sup>2</sup>, E. Poretti<sup>3</sup>, B. Mosser<sup>1</sup>, A. Miglio<sup>4</sup>, J. Montalbán<sup>5</sup>, T. Morel<sup>5</sup>, S. Hekker<sup>6</sup>, Th. Kallinger<sup>7</sup>, Ph. Mathias<sup>8</sup> and the CoRoT team

<sup>1</sup> *LESIA, CNRS, Université Pierre et Marie Curie, Université Denis Diderot, Observatoire de Paris, 92195, Meudon Cedex, France*

<sup>2</sup> *Institut d'Astrophysique Spatiale, UMR8617, CNRS, Université Paris XI, Bâtiment 121, 91405, Orsay Cedex, France*

<sup>3</sup> *INAF - Osservatorio Astronomico di Brera, via E. Bianchi 46, 23807, Merate (LC), Italy*

<sup>4</sup> *School of Physics and Astronomy, University of Birmingham, Birmingham B15 2TT, UK*

<sup>5</sup> *Institut d'Astrophysique et de Géophysique, Université de Liège, Allée du 6 Août, 4000, Liège, Belgium*

<sup>6</sup> *Astronomical Institute 'Anton Pannekoek', University of Amsterdam, Science Park 904, 1098 XH, Amsterdam, The Netherlands*

<sup>7</sup> *Instituut voor Sterrenkunde, K. U. Leuven, Celestijnenlaan 200D, 3001, Leuven, Belgium*

<sup>8</sup> *CNRS, Institut de Recherche en Astrophysique et Planétologie, 14 avenue Edouard Belin, F-31400 Toulouse, France ; Université de Toulouse, UPS-OMP, IRAP, F-31400 Toulouse, France*

**Abstract.** The space mission CoRoT and the ground-based spectrometers HARPS and SOPHIE have observed red giants belonging to the open cluster NGC6633. Solar-like oscillations are detected in the CoRoT data obtained for four red giants. Spectroscopic data questions the cluster membership of one of these stars. The combination of these photometric and spectroscopic data will be a unique opportunity to estimate their global parameters as well as to probe their internal structure.

### **1. Introduction**

Solar-like oscillations have now been detected and analysed in a large sample of red giant stars by the space missions CoRoT (Baglin et al. 2006) and *Kepler* (Borucki et al. 2010). They provide a wealth of unprecedented informations on this kind of stars. Using these seismic data, global parameters such as mass and radius are derived for the first time for a large sample of stars and new constraints on their internal structure are revealed (see Hekker et al., this proceeding, and references therein).

Red giants belonging to clusters are interesting targets since the cluster membership brings additional constraints on some usually unknown parameters (e.g. Stello et al. 2010, 2011). Since stars belonging to a cluster have been formed at the same time, we can assume that they have the same age, distance and metallicity (e.g. Miglio et al. 2012).

In this paper, we present a first view of the data obtained by CoRoT and simultaneous ground based spectrometric observations on red giant stars in the NGC6633 cluster.

## 2. CoRoT oscillation power spectra

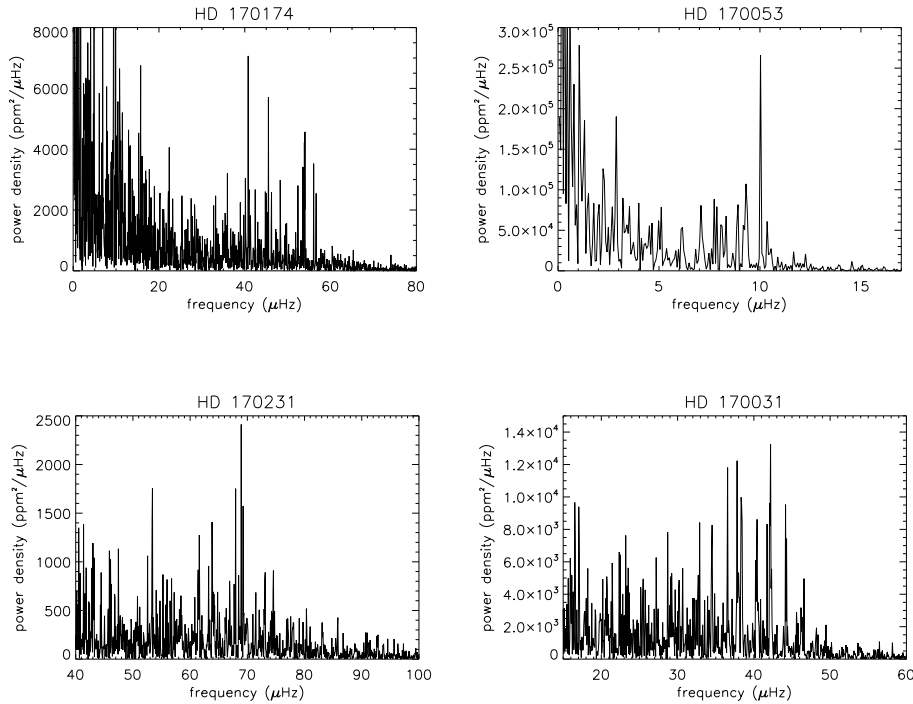


Figure 1. Power spectra of red giants thought to belong to the open cluster NGC6633 computed from CoRoT data.

NGC6633 is an open cluster with a distance of 375 pc (van Leeuwen 2009) and metallicity  $[\text{Fe}/\text{H}] = -0.07 \pm 0.03$  (Jeffries et al. 2002; Paunzen et al. 2010). Four red giant stars of this cluster have been observed by CoRoT during two consecutive long runs spanning 176 days. These four stars clearly show solar-like oscillations as seen in Fig. 1.

## 3. SOPHIE and HARPS spectroscopic data

Simultaneous bi-site ground-based observations of the CoRoT targets belonging to NGC6633 have been performed using the SOPHIE spectrometer coupled to the 193-

cm telescope at Observatoire de Haute-Provence (Bouchy et al. 2009) and the HARPS spectrometer coupled to the 3.6-telescope at La Silla, ESO (Mayor et al. 2003).

The radial velocity obtained for HD 170031 is +16 km/s whereas the radial velocity of the cluster is  $-28$  km/s. HD 170031 might not be a member of NGC6633.

These spectroscopic data will be used to derive the stellar atmosphere parameters of these red giants (Morel et al., in preparation).

The combined HARPS and SOPHIE radial velocity data as well as the CoRoT light curve clearly show similar features (Fig. 2). The Fourier analysis of the ground-based spectroscopic data is in progress to see if we can detect solar-like oscillations in the radial velocity data.

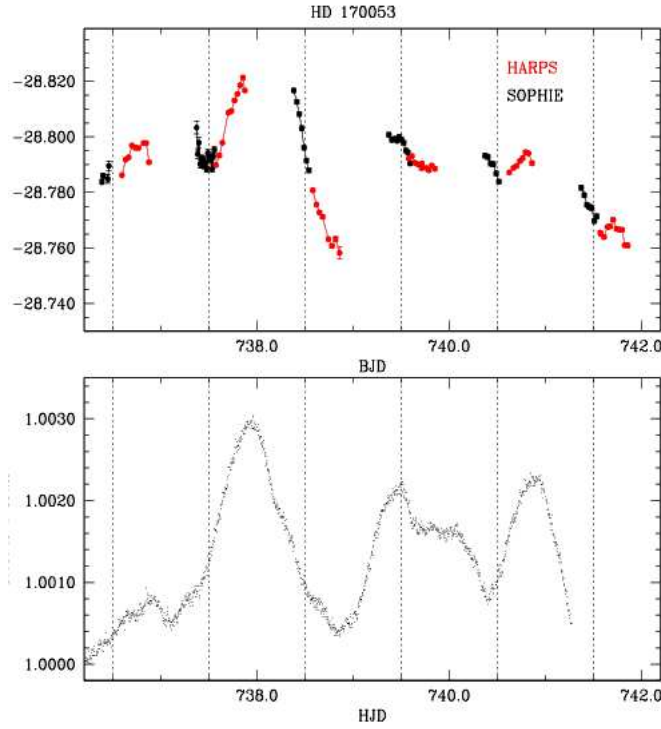


Figure 2. Radial velocity data obtained by HARPS and SOPHIE on HD 170053 (top pannel) as well as CoRoT photmetric data obtained on the same star at the same time (bottom pannel).

#### 4. CoRoT echelle diagrams

For the red giants for which the cluster membership is not questionable, we estimate the individual mode frequencies by fitting a model which is based on Lorentzian profiles and with a MLE method as in Barban et al. (2010).  $\ell = 0$ , mixed  $\ell = 1$  and  $\ell = 2$  modes are clearly detected (Fig. 3).

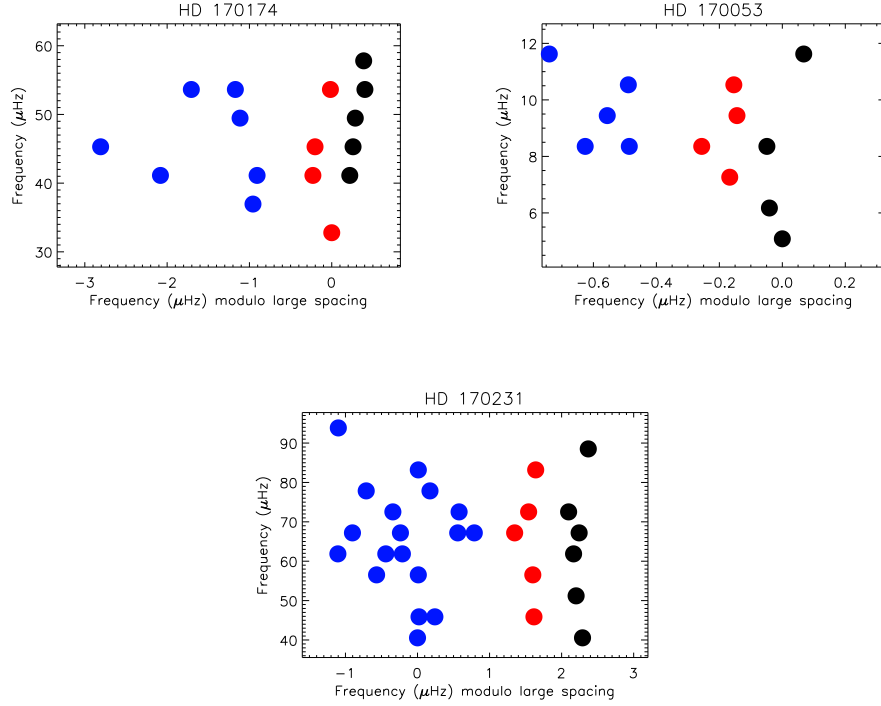


Figure 3. Echelle diagrams computed from individual mode frequencies of three red giants observed by CoRoT and belonging to the open cluster NGC6633. Black symbols correspond to  $\ell = 0$  modes, red symbols to  $\ell = 2$  modes and blue symbols to  $\ell = 1$  modes.

## 5. Conclusion

CoRoT has detected solar-like oscillations in four red giants thought to belong to the open cluster NGC6633. Simultaneous spectroscopic data have been obtained on these stars using HARPS and SOPHIE spectrometers. One of the four red giants is suspected not to belong to the cluster because of its radial velocity estimate. This result needs to be confirmed by a more details analysis of both seismic and spectroscopic data and by modeling these stars (Montalban et al., in prep.)

The combination of these data represent a unique way to test cluster membership of these four red giants. The search for solar-like oscillations in the radial velocity data combined with the CoRoT photometric data will provide a new test on convection treatment via mode amplitude.

The seismic study of red giants in clusters is a promising way for bringing new constraints on stellar evolution and internal structure theory.

**Acknowledgments.** The CoRoT space mission was developed and is operated by the French space agency CNES, with the participation of ESAs RSSD and Science Programmes, Austria, Belgium, Brazil, Germany, and Spain. S.H. acknowledges financial support from the Netherlands Organisation for Scientific research.

## References

- Baglin, A., Auvergne, M., Barge, P., Deleuil, M., Catala, C., Michel, E., Weiss, W., & COROT Team 2006, in *ESA Special Publication*, edited by M. Fridlund, A. Baglin, J. Lochard, & L. Conroy, vol. 1306 of *ESA Special Publication*, 33
- Barban, C., Baudin, F., Mosser, B., Goupil, M. J., De Ridder, J., Samadi, R., Weiss, W. W., Auvergne, M., Baglin, A., & CoRoT Red Giant Team 2010, *Astronomische Nachrichten*, 331, 1016
- Borucki, W. J., Koch, D., Basri, G., Batalha, N., Brown, T., Caldwell, D., Caldwell, J., Christensen-Dalsgaard, J., Cochran, W. D., DeVore, E., Dunham, E. W., Dupree, A. K., Gautier, T. N., Geary, J. C., Gilliland, R., Gould, A., Howell, S. B., Jenkins, J. M., Kondo, Y., Latham, D. W., Marcy, G. W., Meibom, S., Kjeldsen, H., Lissauer, J. J., Monet, D. G., Morrison, D., Sasselov, D., Tarter, J., Boss, A., Brownlee, D., Owen, T., Buzasi, D., Charbonneau, D., Doyle, L., Fortney, J., Ford, E. B., Holman, M. J., Seager, S., Steffen, J. H., Welsh, W. F., Rowe, J., Anderson, H., Buchhave, L., Ciardi, D., Walkowicz, L., Sherry, W., Horch, E., Isaacson, H., Everett, M. E., Fischer, D., Torres, G., Johnson, J. A., Endl, M., MacQueen, P., Bryson, S. T., Dotson, J., Haas, M., Kolodziejczak, J., Van Cleve, J., Chandrasekaran, H., Twicken, J. D., Quintana, E. V., Clarke, B. D., Allen, C., Li, J., Wu, H., Tenenbaum, P., Verner, E., Bruhweiler, F., Barnes, J., & Prsa, A. 2010, *Science*, 327, 977
- Bouchy, F., Hébrard, G., Udry, S., Delfosse, X., Boisse, I., Desort, M., Bonfils, X., Eggenberger, A., Ehrenreich, D., Forveille, T., Lagrange, A. M., Le Coroller, H., Lovis, C., Moutou, C., Pepe, F., Perrier, C., Pont, F., Queloz, D., Santos, N. C., Ségransan, D., & Vidal-Madjar, A. 2009, *A&A*, 505, 853
- Jeffries, R. D., Totten, E. J., Harmer, S., & Deliyannis, C. P. 2002, *MNRAS*, 336, 1109. [arXiv: astro-ph/0206367](#)
- Mayor, M., Pepe, F., Queloz, D., Bouchy, F., Rupprecht, G., Lo Curto, G., Avila, G., Benz, W., Bertaux, J.-L., Bonfils, X., Dall, T., Dekker, H., Delabre, B., Eckert, W., Fleury, M., Gilliotte, A., Gojak, D., Guzman, J. C., Kohler, D., Lizon, J.-L., Longinotti, A., Lovis, C., Megevand, D., Pasquini, L., Reyes, J., Sivan, J.-P., Sosnowska, D., Soto, R., Udry, S., van Kesteren, A., Weber, L., & Weilenmann, U. 2003, *The Messenger*, 114, 20
- Miglio, A., Brogaard, K., Stello, D., Chaplin, W. J., D'Antona, F., Montalbán, J., Basu, S., Bressan, A., Grundahl, F., Pinsonneault, M., Serenelli, A. M., Elsworth, Y., Hekker, S., Kallinger, T., Mosser, B., Ventura, P., Bonanno, A., Noels, A., Silva Aguirre, V., Szabo, R., Li, J., McCauliff, S., Middour, C. K., & Kjeldsen, H. 2012, *MNRAS*, 419, 2077. 1109.4376
- Paunzen, E., Heiter, U., Netopil, M., & Soubiran, C. 2010, *A&A*, 517, A32. 1008.3476
- Stello, D., Basu, S., Bruntt, H., Mosser, B., Stevens, I. R., Brown, T. M., Christensen-Dalsgaard, J., Gilliland, R. L., Kjeldsen, H., Arentoft, T., Ballot, J., Barban, C., Bedding, T. R., Chaplin, W. J., Elsworth, Y. P., García, R. A., Goupil, M.-J., Hekker, S., Huber, D., Mathur, S., Meibom, S., Sangaralingam, V., Baldner, C. S., Belkacem, K., Biazzo, K., Brogaard, K., Suárez, J. C., D'Antona, F., Demarque, P., Esch, L., Gai, N., Grundahl, F., Lebreton, Y., Jiang, B., Jevtic, N., Karoff, C., Miglio, A., Molenda-Žakowicz, J., Montalbán, J., Noels, A., Roca Cortés, T., Roxburgh, I. W., Serenelli, A. M., Silva Aguirre, V., Sterken, C., Stine, P., Szabó, R., Weiss, A., Borucki, W. J., Koch, D., & Jenkins, J. M. 2010, *ApJ*, 713, L182. 1001.0026
- Stello, D., Meibom, S., Gilliland, R. L., Grundahl, F., Hekker, S., Mosser, B., Kallinger, T., Mathur, S., García, R. A., Huber, D., Basu, S., Bedding, T. R., Brogaard, K., Chaplin, W. J., Elsworth, Y. P., Molenda-Žakowicz, J., Szabó, R., Still, M., Jenkins, J. M., Christensen-Dalsgaard, J., Kjeldsen, H., Serenelli, A. M., & Wohler, B. 2011, *ApJ*, 739, 13. 1107.1234
- van Leeuwen, F. 2009, *A&A*, 497, 209. 0902.1039