Characterization of CoRoT variable stars with FLAMES & statistical study of pulsations of Be stars

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Abstract: We present the ground-based ESO/FLAMES observational program set up for the spectroscopic study of variable stars observed in the first CoRoT exoplanet fields. In the IR1, LRA1 and LRC1 fields about 9000 variable stars have been identified by the CVC (CoRoT Variable Classifier). The CVC has already pre-classified about 3000 of them using the CoRoT light curves only. For the rest of them the variable class is unclear. The multi-objects FLAMES medium resolution spectroscopic observation of variable CoRoT stars from the IR1, LRA1 and LRC1 fields will allow us to classify the variable stars accurately and distribute them to the CoRoT AP thematic teams for further analysis. In particular, we will identify the Be stars and determine their fundamental parameters with synthetic spectral fitting. Confronting these parameters to the CoRoT light curves of these objects will allow us to test for correlations between stellar parameters and pulsation properties in a statistical way, in particular to study the instability strips. Moreover, knowing the fundamental parameters of the stars will allow us to perform seismic modeling.

Scientific Context

Stellar oscillations occur at almost all phases of stellar evolution. However, there exists a particular region in the HR diagram in which the density of pulsating stars is more outspoken than elsewhere, called the classical instability strip. This strip is situated between the two vertical dashed lines in Fig. 1 and contains classical Cepheids, RR Lyrae stars, δ Scuti stars and DB white dwarfs. On the blue hot side of the strip one can find high-mass pulsators such as β Cephei, Slowly Pulsating B (SPB) and Be stars. The goal of our program is to obtain one spectrum of each variable star detected by CoRoT in its exo fields, in order to classify them by variable star classes according to their spectra and determine their fundamental parameters. This information is necessary for the seismic modeling of all the pulsating stars observed by CoRoT.

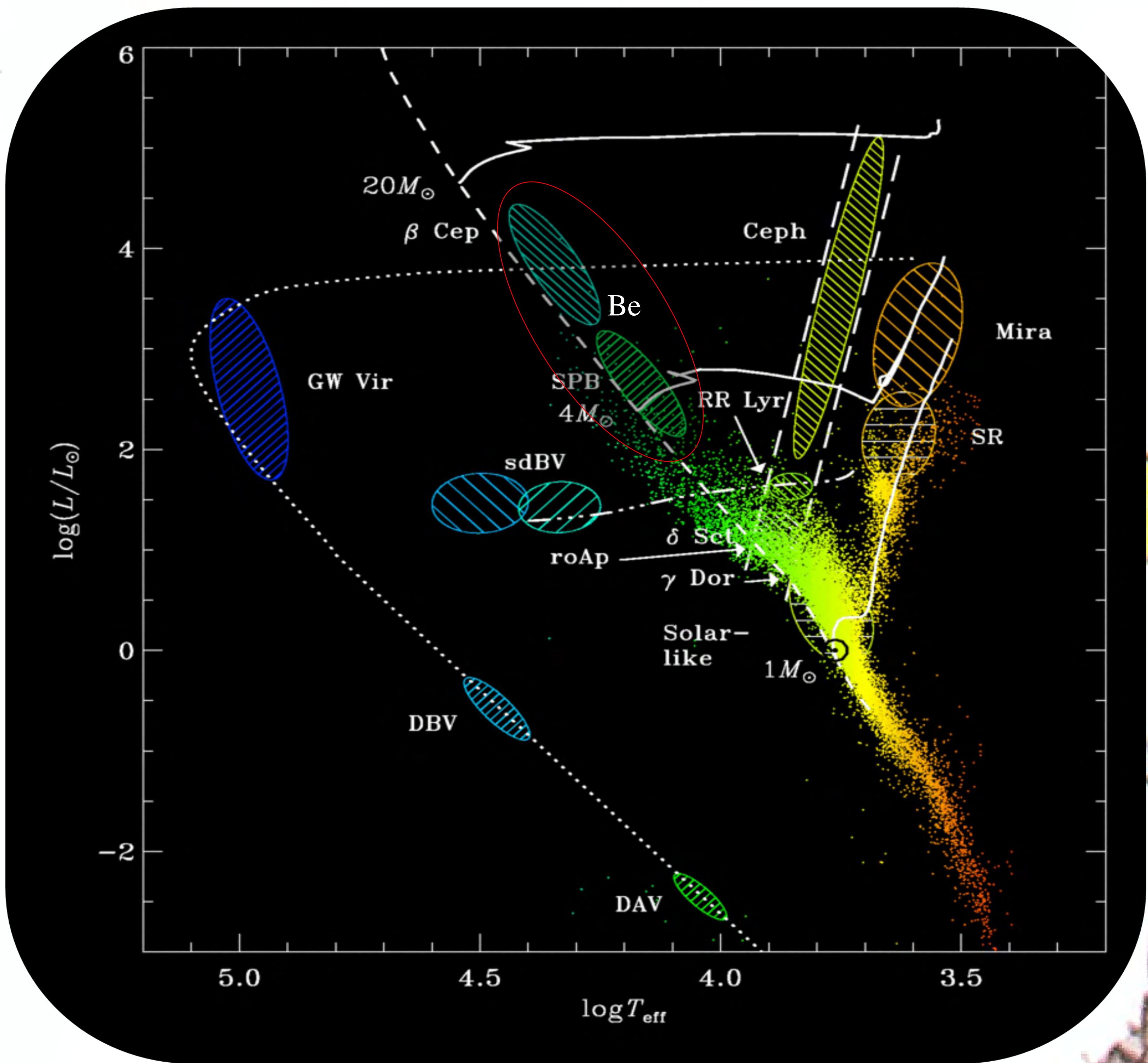

Fig. 1: HR diagram of the pulsating star classes (after the diagram of J. Christensen-Dalsgaard)

Spectral classification and fundamental parameters determination with GIRAFFE

We use the multi-object spectrograph FLAMES/GIRAFFE mounted at UT2 to observe the variable stars detected in the exofields of CoRoT by the CVC. The acquisition of the data of the IR1 and LRA1 fields is ongoing and time has been allocated for the observation of the LRC1 field this summer (Fig. 2).

GIRAFFE allows the simultaneous observation of up to 130 targets (in a field of 25' in diameter). We use two setups: one at λ =4272 Å and R = 6400 (LR2) and one at λ =6438 Å and R = 8600 (LR6).

Thanks to the GIRAFFE LR6 spectra, we will be able to discriminate between the various pulsators observed by CoRoT. The reduced LR6+LR2 GIRAFFE data will then be distributed to the various CoRoT teams according to the classification.

The LR2 spectra will allow each team to determine the parameters of their class of stars. The LR2 spectra contain important lines for all types of stars, in particular two H lines (Hδ and Hγ) and 6 HeI lines at 4009, 4026, 4144, 4388, 4438 and 4471, as well as the SiIII 4552 line. It also contains NII 3995, CII 4267, TiII 4501, FeII 4508,…

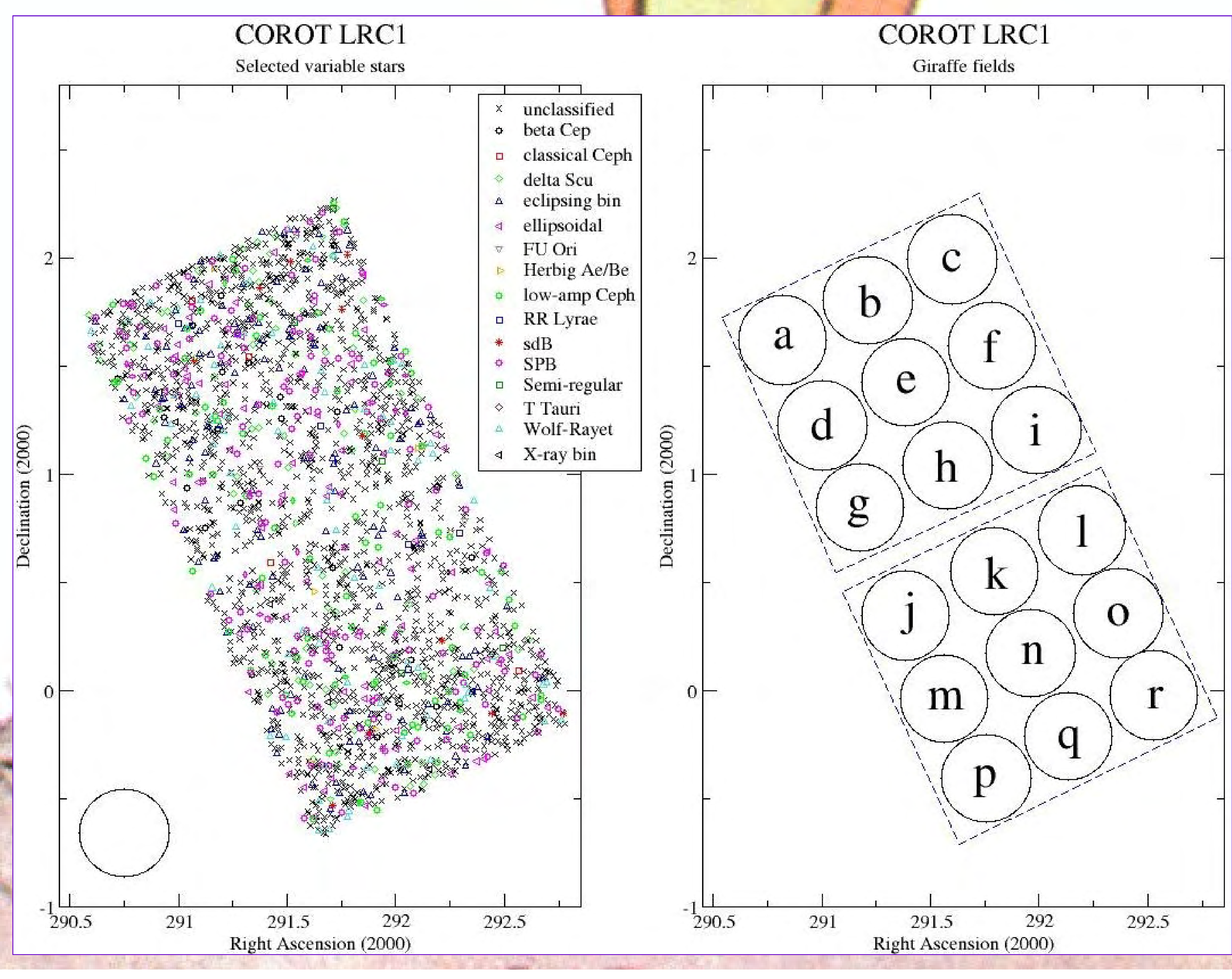

Fig. 2: Example of Giraffe coverage of the CoRoT LRC1 field. Right: The circles indicate the size and position of the Giraffe fields. The 2 squares represent the CoRoT CCDs.

		Stars pre-classified by the CVC																			
Run	**Stars**	BE	BCEP	CLCEP	DSCUT	ELL	GDOR	HAEBE	XB	RRAB	RVTAU	SR	SPB	TTAU	WR	FUORI	SDBV	ECL	RRD	DMCEP	LACEP
IR1	9869	64	53	2	229	64	1	6	4	0	1	2	341	0	48	0	20	151	1	1	271
LRA1	11408	77	44	2	280	95	2	5	7	0	0	1	421	2	49	6	24	178	2	0	117
LRC1	11408	32	23	4	8	93	0	5	7	3	0	5	149	1	76	5	11	135	1	1	97

Need for GIRAFFE spectroscopy

After each CoRoT run, the CoRoT Variable Classifier (CVC) identifies variable stars among all observed stars of the EXO program and tries to roughly classify them into categories of variables. However, the CVC cannot discriminate certain types of variables. For example there is strong confusion between SPB and Be stars (same pulsations but Be stars rotate faster and have a disk). The Table shows the number of stars classified with a good confidence by the CVC. For all the other stars, only a spectrum can help to obtain a reliable classification..

In addition, to perform a seismic modeling of the variable stars and deduce their internal structure, the fundamental parameters (temperature, gravity, vsini) as well as the abundances of the stars are needed. Again only a spectrum allows to perform an accurate determination of the parameters

Fundamental parameters of Be stars

Be stars are defined as B stars that show or have shown at least once emission in their Balmer lines. This emission is due to the presence of a circumstellar disk built from matter ejected from the star though outbursts. The presence of this emission and the rapid rotation of Be stars require special care when determining their fundamental parameters.

Our team will determine the fundamental parameters of all Be stars observed by CoRoT thanks to the FASTROT/GIRFIT code, which takes into account the effects of rapid rotation.

Conclusion

The spectroscopic GIRAFFE data will allow us to refine the CVC classification of the variable stars observed in the exofields of CoRoT. The thematic AP teams of CoRoT will then be able to determine the fundamental parameters of the stars for each studied class and use those to constraints seismic modeling. In the case of Be stars we will study the possible correlation between these fundamental parameters, the pulsational properties and the outbursts of Be stars.