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Unveiling stellar multiplicity
High-resolution spectroscopic follow-up of LAMOST discoveries *

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The evolution of a star in a gravitationally bound stellar system can be significantly influenced by the proximity of its companion(s). However, the full range of these effects remains incompletely understood. Double-lined binaries and higher-order multiple-lined systems offer a clear advantage: the characteristics of more than one component can be extracted from high-resolution spectroscopy, providing stronger constraints for modeling efforts. In 2023, we initiated a spectroscopic follow-up program using the High Efficiency and Resolution Mercator Echelle Spectrograph (HERMES), mounted on the 1.2-m Mercator Telescope at the Roque de los Muchachos Observatory (La Palma, Canary Islands, Spain). The goal is to obtain spectroscopic data for an initial characterization of candidate double-lined and triple-lined systems recently identified by Frasca et al. (2022, A&A 664, A78) using medium-resolution observations from the Large Sky Area Multi-Object Fibre Spectroscopic Telescope (LAMOST) survey at Xinglong Observatory (Xinglong, China). For a comprehensive analysis, these new spectra will be combined with ground-based data from other facilities and with space-based light curves from the Kepler and TESS missions, in order to improve our understanding of these systems. In this poster, we present the first results after 1.5 years of HERMES observations. The project also stands to benefit from future observations with the high-resolution spectrograph that will be installed on the 3.6-m Devasthal Optical Telescope (DOT) at Devasthal Observatory (India), which will enable the study of fainter targets.

Observations

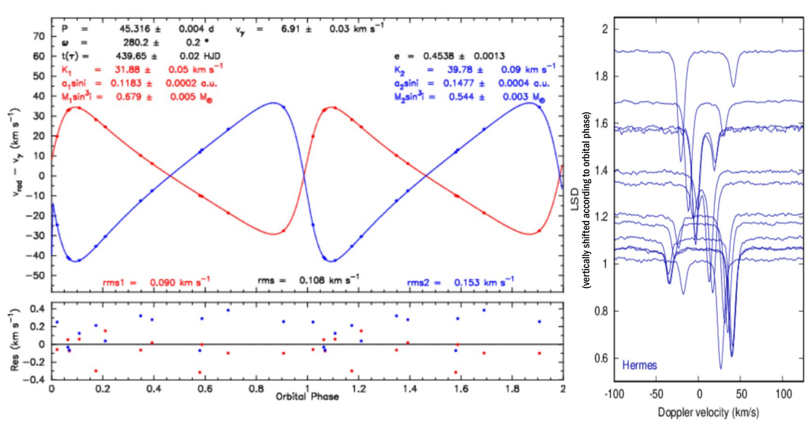
- Telescope: 1.2-m Mercator (Roque de los Muchachos Observatory, La Palma, Spain)
- Instrument: HERMES (High Efficiency and Resolution Mercator Echelle Spectrograph)
  - Wavelength range: 377-900 nm (55 échelle orders)
  - Spectral resolution: R ≈ 85 000
  - Second fiber: sky spectrum
  - Throughput: >25% in V band
  - Radial velocity stability: ~2.5 m s^{-1}
- Observing period: cycles 2024A, 2024B, and 2025A (Apr 2024 – Sep 2025)
- Observing strategy: optimal coverage of orbital phases
- Reduction: HermesDRS (data reduction pipeline) + continuum normalisation

1.2-m Mercator telescope
(Roque de los Muchachos Observatory, La Palma, Spain)

Analysis

- LSD (least-squares deconvolution) profiles (Donati, 1997, MNRAS 291, 658)
  - Wavelength range: 500-580 nm
  - Line mask (depth > 1%): based on star with T_{eff} = 7 000 K, log$g$ = 4.0 dex, solar abundances
- Radial velocity determination:
  - Fit ting the LSD profiles with n Gaussian functions (n = number of detected components in spectra)
- Orbit determination:
  - Fortran code: VCURVE (following the formalism of Bertiau & Grobben, 1969, RA 8, 1)
- Figures:
  - Top left: observed radial velocity as a function of orbital phase (red = primary, blue = secondary)
  - Bottom left: residual radial velocities after subtraction of the orbital solution
  - Right: LSD profiles, vertically shifted according to orbital phase

KIC 4243697



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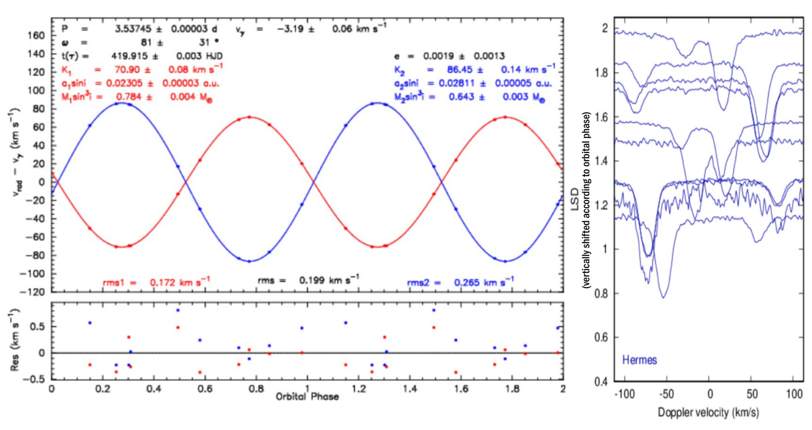

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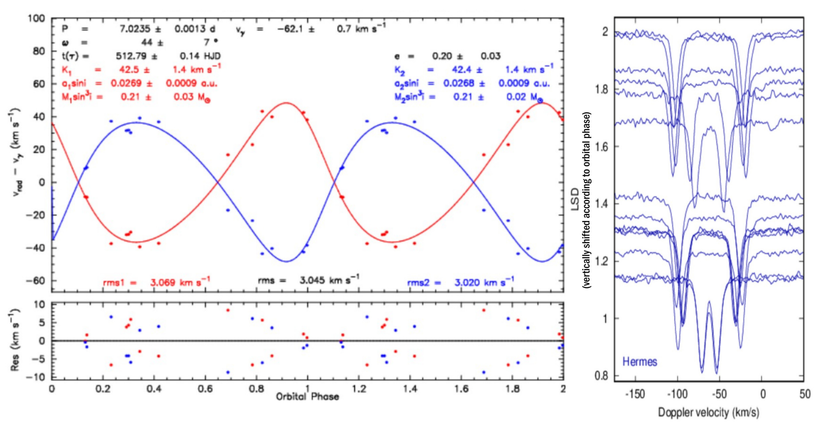

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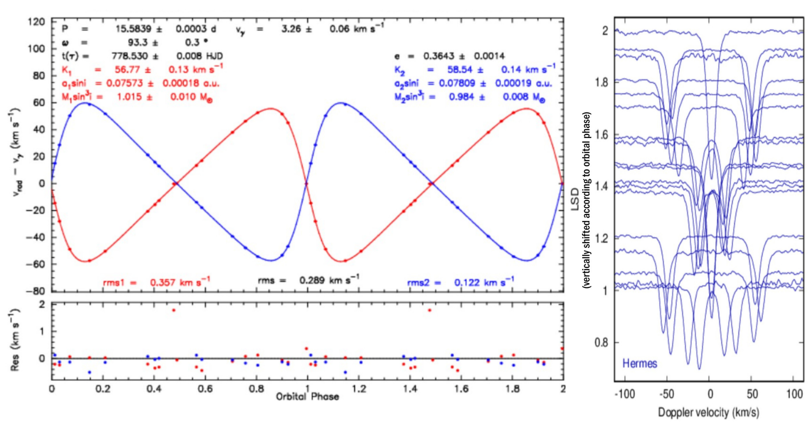

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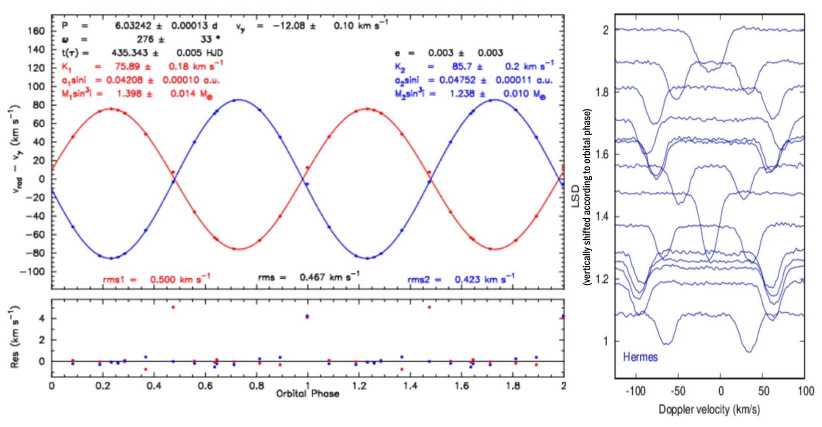


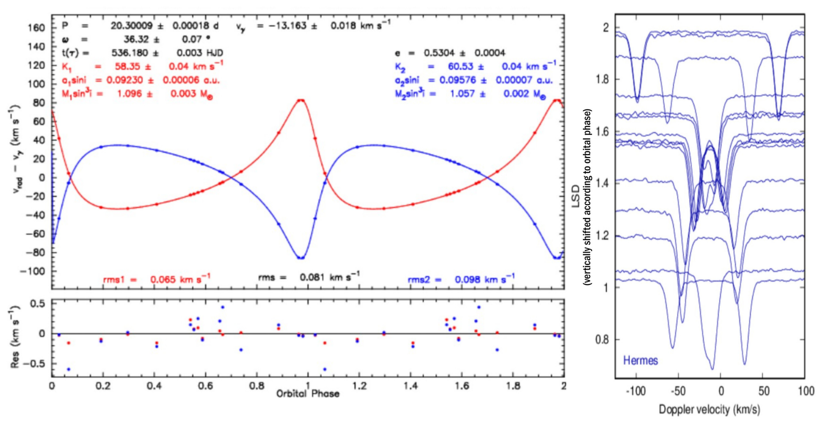
Targets and available data sets

KIC number	TIC number	RA (J2000)	DEC (J2000)	V (mag)	HERMES	RESULT	LAMOST-MRS group	LAMOST-MRS epoch	TESS sectors
4243697	120573355	19:02:08.98	+39:18:09.7	10.5	#12	SB2	#2	#7	#8
4819301	120821409	19:04:58.70	+39:54:54.9	13.1	#10	SB2	#1	#3	#8
6431515	121331529	19:11:15.71	+41:52:21.0	12.5	#14	SB2	#6	#19	#11
6754169	164411943	18:51:40.38	+42:13:10.3	10.7	#18	SB2	#1	#3	#9
6764812	158553410	19:10:27.57	+42:14:29.7	11.1	#10	SB3	#12	#52	#10
8031672	63374719	19:31:25.77	+43:52:58.6	10.6	#14	SB2	#9	#47	#10
8502619	271161607	19:38:19.10	+44:34:41.7	10.7	#15	SB2	#4	#17	#10
8633160	271351281	19:39:43.94	+44:46:09.5	11.5	#13	SB2	#1	#4	#9
9033354	271883105	19:42:53.87	+45:19:13.1	11.1	#15	SB2	#4	#17	#10
9830839	62917894	19:26:53.22	+46:36:46.8	10.9	#12	SB2	#5	#18	#10
110395363	158489800	19:10:22.82	+47:30:05.0	11.4	#16	SB2	#2	#6	#13
10661074	267668801	19:19:55.42	+47:59:31.8	10.9	#13	SB2	#1	#3	#11
11077129	298893712	19:12:41.96	+48:39:14.6	11.1	#16	SB2	#1	#3	#12

This poster

Orbital solution derived from HERMES spectra

KIC 8502619



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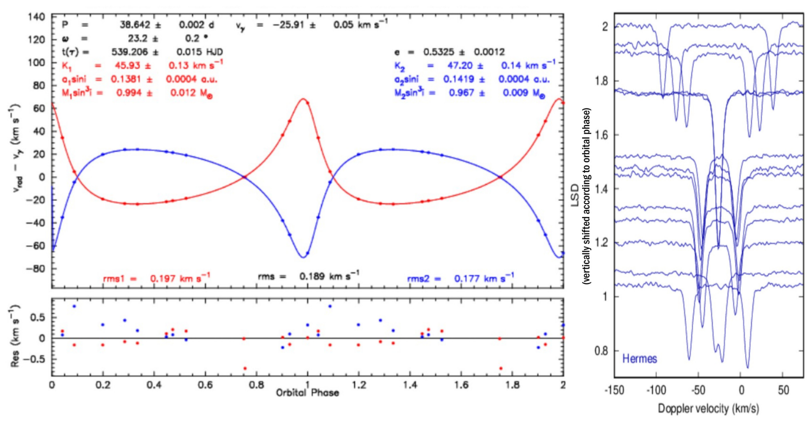

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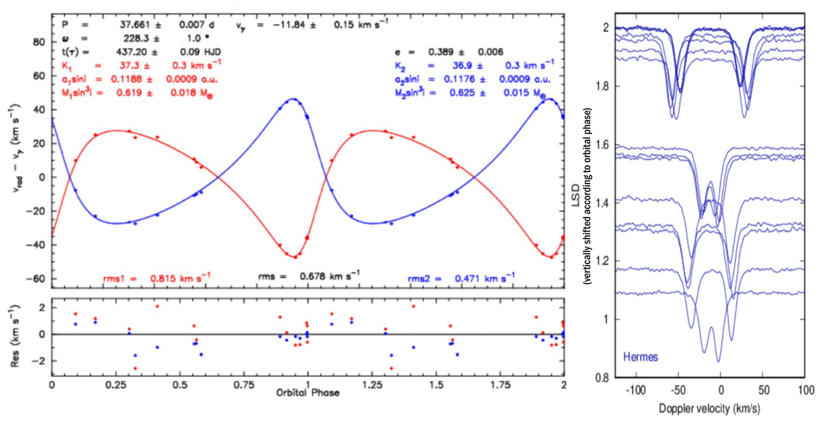

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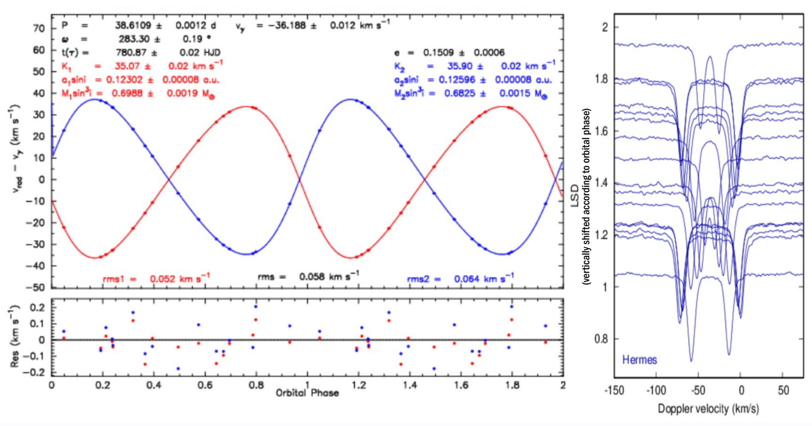

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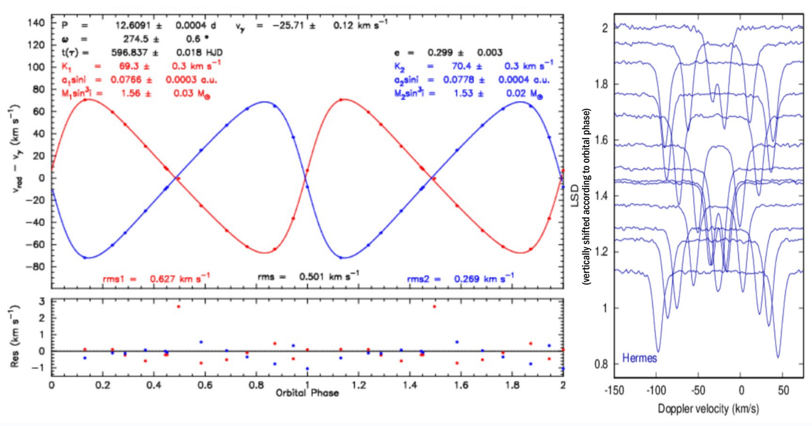

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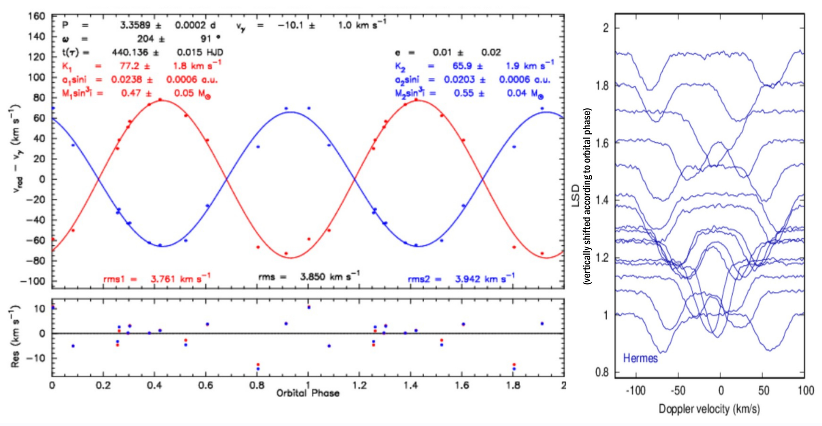

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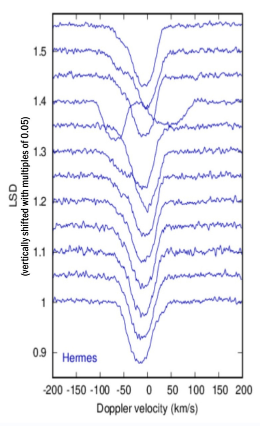

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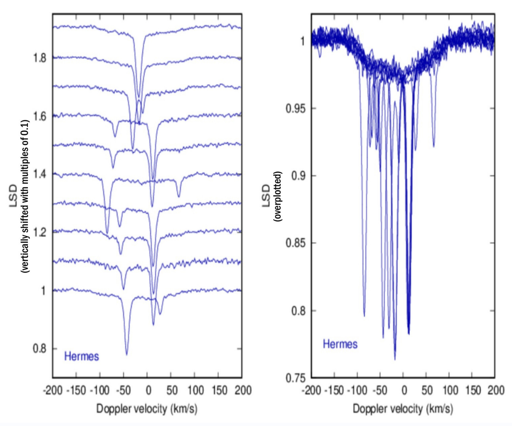

Conclusions

All the studied objects have been confirmed to be multiple systems, of which ten are double-lined (SB2) and one is triple-lined (SB3).
An orbital solution has been derived from the available high-resolution HERMES spectra for all systems except two.

* Based on observations made with the Mercator Telescope, operated on the island of La Palma by the Flemish Community, at the Spanish Observatorio del Roque de los Muchachos of the Instituto de Astrofísica de Canarias. Based on observations obtained with the HERMES spectrograph, which is supported by the Research Foundation - Flanders (FWO), Belgium, the Research Council of KU Leuven, Belgium, the Fonds National de la Recherche Scientifique (F.R.S.-FNRS), Belgium, the Royal Observatory of Belgium, the Observatoire de Genève, Switzerland and the Thüringer Landessternwarte Tautenburg, Germany.

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