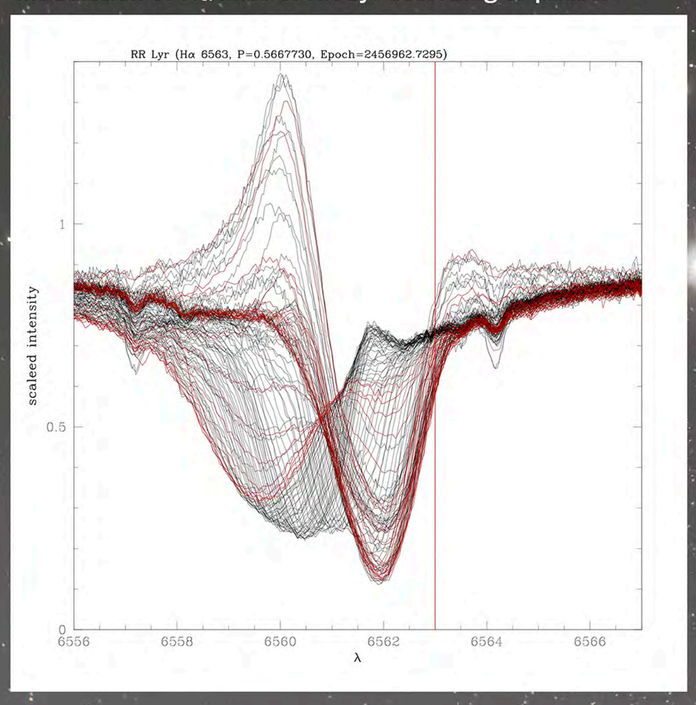
# Spectroscopic observations of the field RR Lyrae variable stars at BOAO

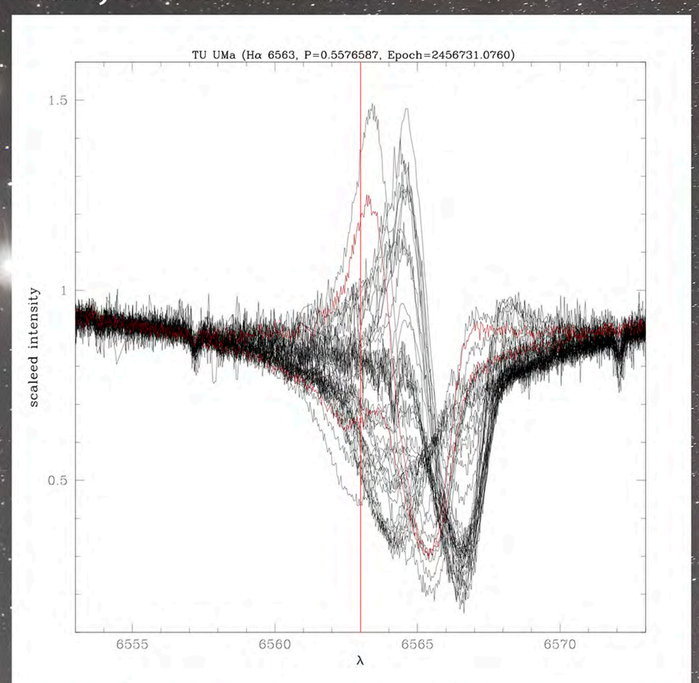
Young-Beom Jeon; Hyung-il Oh
Korea Astronomy and Space Science Institute

Since 2017, we have been continuously performing time-series spectroscopic observations of the bright field RR Lyrae variable stars for about 10 days every year. The observation targets are SU Dra, TU UMa, X Ari, RZ Cep, SW And, and RR Lyr. The observation equipment used is the BOES Echelle spectrograph at the Bohyunsan Optical Astronomical Observatory (BOAO). At first, we used the R=30,000 mode, and from 2024, we used the 2x2 binning mode to R=15,000, expecting a better S/N ratio. RR Lyr was exposed for 600 seconds because it was bright, but the rest were exposed for 1800 seconds and 900 seconds depending on weather or seeing conditions. We will summarize and present the results of our research so far.

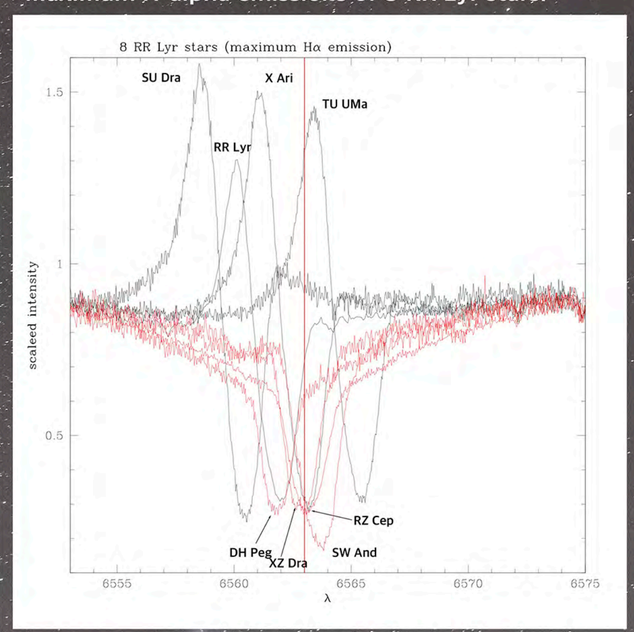
Modulation of Hα lines of RR Lyr according to phase.




Binarity evidence of TU UMa




Maximum H-alpha emissions of 8 RR Lyr stars.




Observation Log

| Target | Year | Month | Date | Phase start | Phase end | Exp (s) |
|---|---|---|---|---|---|---|
| RR Lyr (RRab-BL) | 2024 | 4 | 25 | 0.796 | 0.965 | 600 |
| | | | 26 | 0.560 | 0.792 | |
| | | | 27 | 0.306 | 0.602 | |
| | | 5 | 1 | 0.345 | 0.641 | |
| | | | 14 | 0.348 | 0.515 | |
| | | | 16 | 0.748 | 0.057 | |
| | | | 17 | 0.478 | 0.827 | |
| | | | 19 | 0.101 | 0.346 | |
| | | | 21 | 0.534 | 0.868 | |
| | | | 23 | 0.055 | 0.364 | |
| | 2021 | 5 | 2 | 0.468 | 0.655 | |
| | | | 5 | 0.579 | 0.965 | |
| | | | 7 | 0.112 | 0.492 | |
| | | | 9 | 0.761 | 0.989 | |
| | | | 12 | 0.938 | 0.294 | |
| | | | 13 | 0.696 | 0.055 | |
| | 2019 | 4 | 17 | 0.352 | 0.428 | 1200 |
| | P=0.566730 | | | | | |
| | Ephoch_0=2456962.7295 | | | | | |

| Target | Year | Month | Date | Phase start | Phase end | Exp (s) |
|---|---|---|---|---|---|---|
| TU UMa (RRab) | 2024 | 4 | 25 | 0.703 | 0.051 | 900 |
| | | | 26 | 0.487 | 0.846 | |
| | | | 27 | 0.287 | 0.621 | |
| | | 5 | 1 | 0.466 | 0.775 | |
| | | | 14 | 0.783 | 0.150 | |
| | | | 16 | 0.413 | 0.606 | |
| | | | 17 | 0.196 | 0.331 | |
| | | | 19 | 0.773 | 0.985 | |
| | | | 21 | 0.359 | 0.514 | |
| | | | 22 | 0.182 | 0.317 | |
| | 2022 | 11 | 17 | 0.887 | 0.990 | |
| | 2021 | 5 | 2 | 0.921 | 0.315 | |
| | | | 5 | 0.276 | 0.510 | |
| | | | 7 | 0.894 | 0.102 | |
| | | | 8 | 0.668 | 0.768 | |
| | | | 9 | 0.479 | 0.811 | |
| | | | 12 | 0.854 | 0.061 | |
| | | | 13 | 0.626 | 0.857 | |
| | 2019 | 4 | 17 | 0.277 | 0.682 | |
| | | | 20 | 0.580 | 0.885 | |
| | | 11 | 12 | 0.607 | 0.666 | |
| | | | 13 | 0.323 | 0.460 | |
| | | | 14 | 0.183 | 0.261 | |
| | 2018 | 11 | 9 | 0.622 | --- | |
| | | | 10 | 0.491 | 0.530 | 1800 |
| | | | 22 | 0.922 | 0.042 | |
| | | | 25 | 0.313 | 0.466 | |
| | | | 26 | 0.062 | 0.254 | |
| | P=0.5576587 | | | | | |
| | Ephoch_0=2456731.076 | | | | | |

| Target | Year | Month | Date | Phase start | Phase end | Exp (s) |
|---|---|---|---|---|---|---|
| X Ari (RRab) | 2022 | 11 | 9 | 0.173 | 0.457 | 900 |
| | | | 11 | 0.441 | 0.619 | |
| | | | 16 | 0.995 | 0.031 | |
| | | | 17 | 0.542 | 0.827 | |
| | | | 18 | 0.193 | 0.299 | |
| | | | 20 | 0.921 | 0.401 | |
| | 2019 | 11 | 12 | 0.663 | 0.033 | |
| | | | 13 | 0.448 | 0.515 | |
| | | | 14 | 0.755 | 0.090 | |
| | | | 15 | 0.282 | 0.399 | |
| | | | 19 | 0.316 | 0.434 | |
| | 2018 | 11 | 10 | 0.945 | 0.081 | 1800 |
| | | | 20 | 0.529 | 0.661 | |
| | | | 22 | 0.465 | 0.769 | |
| | | | 23 | 0.956 | 0.100 | |
| | | | 25 | 0.212 | 0.385 | |
| | | | 26 | 0.458 | 0.884 | |
| | P=0.6511628 | | | | | |
| | Ephoch_0=2452894.895 | | | | | |

| Target | Year | Month | Date | Phase start | Phase end | Exp (s) |
|---|---|---|---|---|---|---|
| SU Dra (RRab) | 2020 | 3 | 20 | 0.468 | 0.007 | 1500 |
| | | | 21 | 0.092 | 0.295 | |
| | | | 22 | 0.511 | 0.101 | |
| | | 4 | 7 | 0.735 | 0.295 | 900 |
| | | | 8 | 0.264 | 0.807 | |
| | | | 10 | 0.253 | 0.423 | |
| | 2019 | 4 | 15 | 0.694 | 0.203 | 1500 |
| | | | 17 | 0.674 | 0.728 | |
| | P=0.660417 | | | | | |
| | Ephoch_0=2456900.5065 | | | | | |

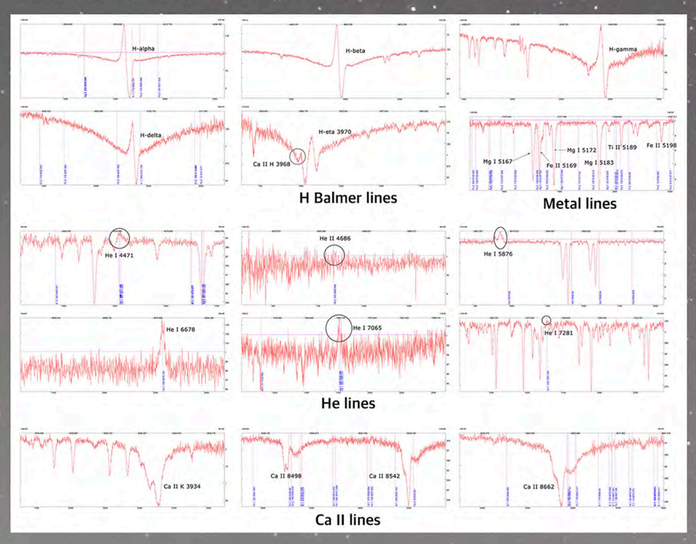
| Target | Year | Month | Date | Phase start | Phase end | Exp (s) |
|---|---|---|---|---|---|---|
| XZ Dra (RRab-BL) | 2019 | 11 | 12 | 0.682 | 0.978 | 1200 |
| | | | 14 | 0.890 | 0.211 | 900 |
| | | | 15 | 0.975 | 0.296 | |
| | | | 16 | 0.132 | 0.429 | |
| | | | 19 | 0.387 | 0.503 | |
| | P=0.476494 | | | | | |
| | Ephoch_0=2456867.3974 | | | | | |

| Target | Year | Month | Date | Phase start | Phase end | Exp (s) |
|---|---|---|---|---|---|---|
| DH Peg (RRc) | 2022 | 11 | 17 | 0.251 | 0.987 | 600 |
| | P==0.255514 | | | | | |
| | Ephoch_0=2456961.3926 | | | | | |

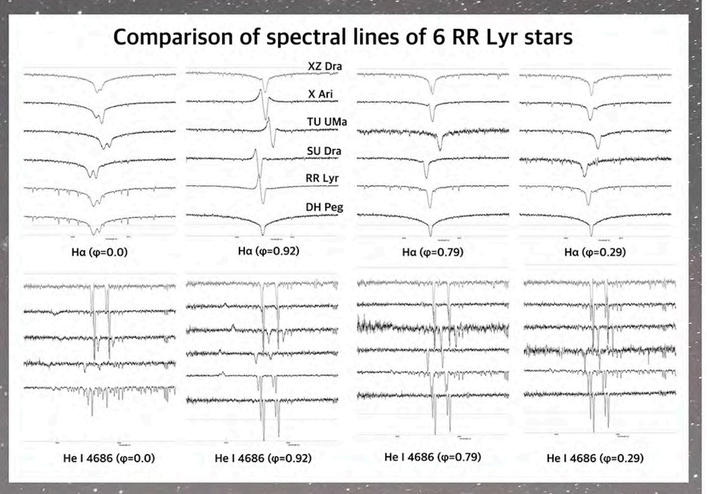
| Target | Year | Month | Date | Phase start | Phase end | Exp (s) |
|---|---|---|---|---|---|---|
| SW And (RRab-BL) | 2022 | 11 | 10 | 0.748 | 0.870 | 900 |
| | | | 17 | 0.921 | --- | |
| | | | 18 | 0.726 | 0.198 | |
| | P=0.442263 | | | | | |
| | Ephoch_0=2456892.4134 | | | | | |

| Target | Year | Month | Date | Phase start | Phase end | Exp (s) |
|---|---|---|---|---|---|---|
| RZ Cep (RRc) | 2018 | 11 | 10 | 0.011 | 0.182 | 1800 |
| | | | 20 | 0.374 | 0.070 | |
| | | | 22 | 0.908 | 0.187 | |
| | | | 23 | 0.118 | 0.403 | |
| | | | 26 | 0.769 | 0.905 | |
| | P=0.3086853 | | | | | |
| | Ephoch_0=2442635.3221 | | | | | |

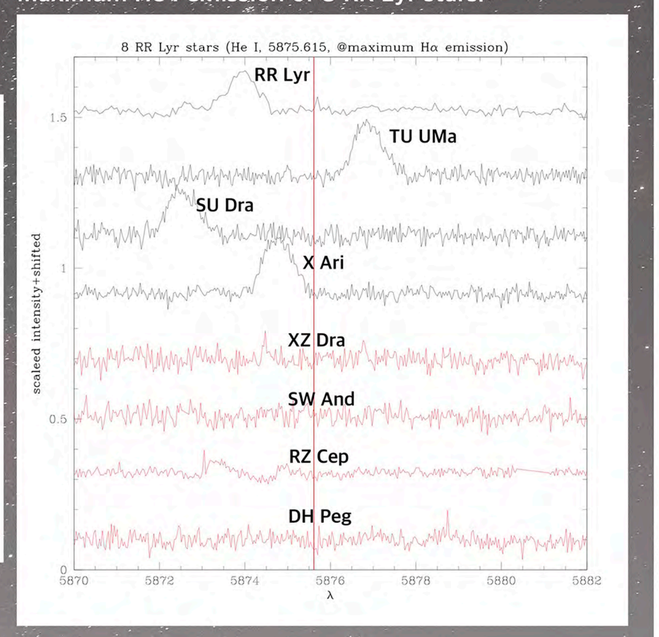
Detected spectral lines of RR Lyr itself



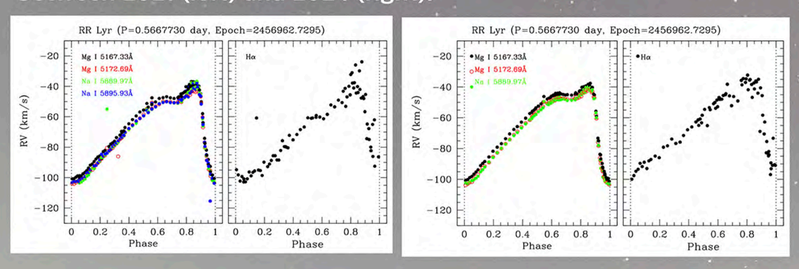

Comparison of spectral lines of 6 RR Lyr stars




Maximum He I emission of 8 RR Lyr stars.



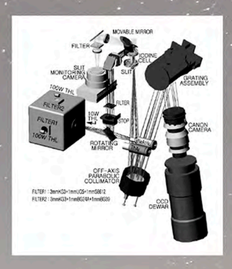

Radial velocity comparison of RR Lyr between 2021 (left) and 2024 (right).



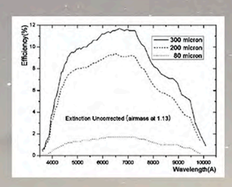




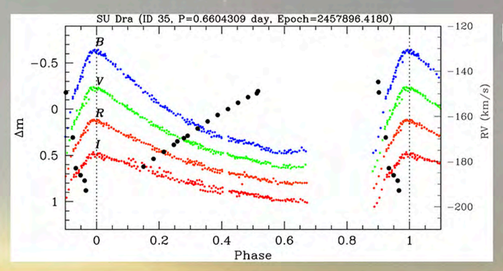
BOES Spectrograph (From Kim et al. 2007, PASP 119, 1052)



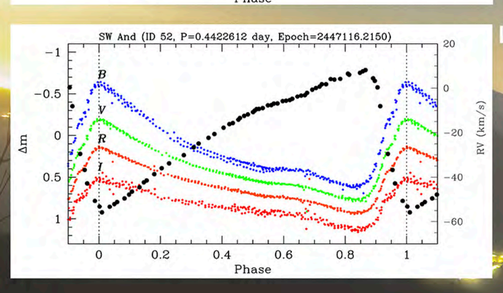

Optical layout of BOES CIM, showing long-slit spectrograph (right), slit-monitoring device (left), and calibration lamp unit ( front). Fiber input of the fiber assembly (omitted in the figure) is located at the slit position



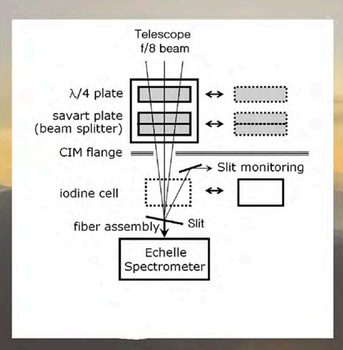

Measured efficiency of the (BOES + telescope + air extinction) for different single fibers without the correction of the light cutoff at the fiber input while the star was at 1.13 air mass with the seeing around 2.3" on 2003 November 3.




Light curves & RV of SU Dra



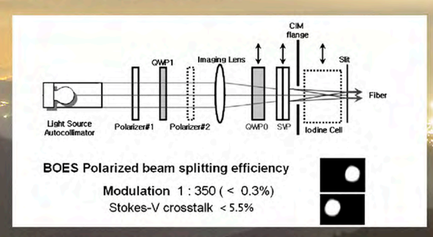

Light curves & RV of SW And



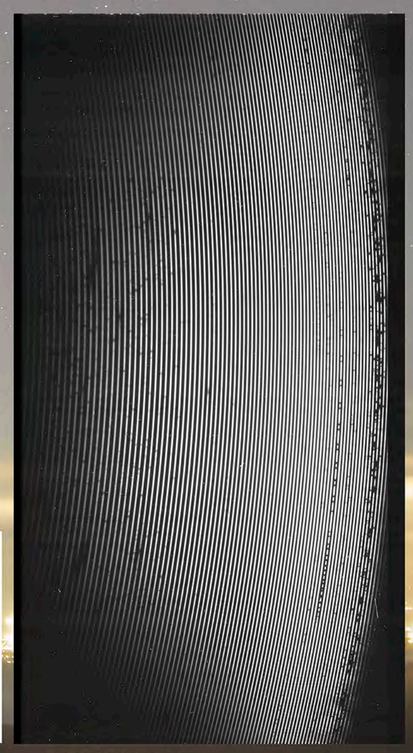

Optical layout of the polarimetric optics in front of the CIM of the 1.8 m telescope.

BOES has an iodine cell to get a very precise RV, and has a polarimeter.

references
Kim et al. 2007, PASP, 119, 1052
Lee et al. 2011, JKAS, 44, 67




Optical layout of the modulation and cross talk measurements,



sample image

If anyone needs these data, please let me know.
I would like to share the data.

ybjeon00@gmail.com