Asteroseismology

Aims:
• The detailed precise spectroscopic and photometric studies of stellar pulsations across the Hertzsprung–Russell (H-R) diagram in order to get knowledge about pulsation spectra, pulsational behavior and properties of stars at different evolutionary stages.

Methods:
• We are using asteroseismology, stellar spectroscopy and photometric light curve analyses and modeling techniques to get this knowledge.

Sub-projects:
• The rapidly oscillating magnetic (roAp) stars (sub-project (A));
• Pulsating components of Algols (oEA stars) (sub-project B)
  • Pulsating A-F type stars (sub-project C):
Sub-project B: oEA (oscillating EA) stars:

The A-F spectral type mass-accreting Main Seguence pulsating stars in a semi-detached, Algol-type systems (Mkrtichian et al., 2002)

The most remarkable peculiarity of oEA stars is co-existence of mass-accretion and pulsations, evolutionary track along the MS

$P_{\text{puls}} > 21\text{min}$
Find the pulsation frequencies on primary components of oEA stars.

Parameters: masses, radii, temperature etc. for components and binary orbital parameters
Thai Sky Survey for oEA Stars (THASSOS), NARIT Robotic Telescope Network

0.6m, PROMPT8 at CTIO.

0.5m, TNO

0.7m Gaomeigu Observatory, China

0.7m Sierra Remote Observatory, USA.

The Siding Brook Observatory (Australia).
Spectroscopic Survey of oEA stars on SALT 11m tel. & 2.4m tel.
“The asteroseismology of the mass-accreting stars”

- More than 50 visits/night, each consist of 5-20 high-resolution spectra (now ongoing, last visit on 29 July).
- Orbits, detection of high-degree NRPs, chemical composition
- Majority of oEA stars show non-radial pulsations

AS Eri
Fig. 5 Acoustic oscillation spectrum of GQ TrA

(Δν is a travelling time of acoustic wave across the diameter of a star).

Δν = 8.32 c/d ~ 2.88 hours
RZ Cas system: We detected of ~6-9 year cyclic variations of P(orb) which is most likely caused by magnetic activity cycle of a donor star.
RZ Cas: the first detection of simultaneous (accretion driven) abrupt changes in the orbital period and pulsation spectrum

- Detection of orbital period jump

- Detection of O-C jump
  
  \[1.6 \times 10^{-6} \text{ Mo/yr}\]

- Detection of amplitude variations

- The first detection of frequency variations=acceleration & braking
RZ Cas
Spectroscopic modeling of absorption/emission lines and gas accretion and envelopes in oEA stars

• We found in oEA stars spectroscopically, the excitation of variable vs orbital phase He I lines in the zone of gas-stream atmosphere interaction.

• Having 3-D hydrodynamic simulations we (with A. Dodin - a PhD student from Moscow State University, Russia) build a model of accretion-induced excitation of He I lines in the high-temperature (100,000 K) optically thin gas envelope.
Observed and modeled (red line) orbital variations of He I 5876 Å line
Sub-project B

- The ongoing oEA photometric survey using NARIT telescopes discovers 2 new systems in 2017-2018 fiscal year.
- We discovered 11 new variable stars in the field of oEA star CX Car.
- The new orbital parameters of RXHya, GQTrA, RCMa, AO Ser, have been determined.
- We discovered the excitation of high-degree NRPs in majority of oEA stars
- For the first time, we discovered a direct influence of mass-accretion on pulsations of RZ Cas gainer and on spin acceleration of its subphotospheric layers.
- We did 3-D hydrodynamic simulations showing that RZ Cas is a direct gas stream-atmosphere impactor and there is a hot turbulent zone where the gas stream hits the atmosphere.
- We found remarkable variability of intensity of the He I absorption/emission lines with the orbital phase, observationally confirming existence of the hot spot in the atmosphere of gainer.
- Our 3-D simulations help us to model a hot impact zone (100,000 K) using simple model of hot envelope which confirms observational finding.
- We conclude, that the direct gas stream-atmosphere impactors among Algols could be found by detection of He I lines amplification at the orbital phases of visibility of impact zones.
Subproject A: 
Asteroseismology and atmospheric tomography of roAp stars: 
Gam Equ

We developed the acoustic tomographic technique of vertical cross-sections of atmosphere using spectral lines formed at different atmospheric heights.

The acoustic oscillation spectrum with 65 µHz spacing

The acoustic-cross section for Gamma Equ and found ionic separation of REE of the first (II) and the second (III) ionization stages.
Further development of tomographic technique: Alp Circini
Acoustic amplitude-phase diagram for two acoustic frequencies 2442 and 2472 $\mu$Hz
We are working on tailoring the atmospheric height from different lines/elements to restore the full acoustic profile across the atmosphere.
Subproject C:

• **Spectroscopy of pulsating Delta Scuti Star 1 Mon**

  We completed the campaign on 1 Mon, telescopes 6.0m SAO, 1.8 KASI, 1.0m Russia, Korat 0.6m. We are working on the data.

• **Daytime Doppler spectroscopy for asteroseismology and exoplanet search:**

  We are working on the reduction and analysis of a new set of experimental daytime observations of Polaris, Beta Per and Beta CrB obtained at Korean 1.8m telescope on 26-28 Jan. 2018
Refereed journals:


Other publications:

1. Discovery of short-period oscillations in the mass-accreting component of TT Vel', Mkrtichian D.E., Gunsriiwat K., Reichart, D. E., Haislip, J. B., Kouprianov, V. V., Poshyachinda, S., 2018, IBVS, No. 6238, Vol. 63 [IF=0.32]

2. Binarity and Variable Stars in the Open Cluster NGC 2126, Chehlaeh, Nareemas; Mkrtichian, David; Kim, Seung-Lee; Lampens, Patricia; Komonjinda, Siramas; Kusakin, Anatoly; Glazunova, Ljudmila, 2018, BSRSL, 87, 216

Conference participation and talks/posters:

- The 5th Sino-Thai Symposium on High Energy Physics, Astrophysics and Beyond (STSP 2018), Lijiang, China, July 18-21 2018: 3 oral talks
- SPC 2018: 2 oral talks
- Big data workshop in the NARIT-ICRAR workshop on “Data intensive astronomy”, February 5-9, Chiang Mai, Thailand.
- Young astronomer school in The International School for Young Astronomers on Stars and Exoplanets, November 26- December 9, Kunming, China.
- High resolution spectroscopy workshop in the 9th Xinglong Observational Astrophysics, October 31- November 6, Beijing, China.
Submitted proposals for joint international projects:

• “Polarimetry of Algol systems”
  Georgian Academy Sciences, submitted on July 25, 2018
  (PI) Dr. T. Kvernadze, Abastumani Astrophysical Observatory, Georgia

• “Variable stars at different evolutionary stages”
  Indo-Thai call for proposals, submitted on 15 July, 2018
  (PI) Dr. A. Ghoswami (IIA), Sr. S. Joshi (ARIES),
  (PI) Dr. S. Mkrtichian, Dr. N. Tanakul (NARIT), K. Gunsriwiwat, N. A-thano