Kateryna Kravchenko

Title

Tomography of evolved star atmospheres

Abstract

Cool giant and supergiant stars are among the largest and most luminous stars in the Universe and, therefore, dominate the integrated light of their host galaxies. These stars were extensively studied during last few decades, however their relevant properties like photometric variability and mass loss are still poorly constrained. Understanding of these properties is crucial in the context of a broad range of astrophysical questions including chemical enrichment of the Universe, supernova progenitors, and the extragalactic distance scale.

The atmospheres of evolved stars are characterized by complex dynamics due to different interacting processes, such as convection, pulsation, formation of molecules and dust, and the development of mass loss. These dynamical processes impact the formation of spectral lines producing their asymmetries and Doppler shifts. Thus, by studying the line-profile variations on spatial and temporal scales it is possible to reconstruct atmospheric motions in stars and link them to the photometric variability and mass loss. The tomographic method, which is based on the cross-sectioning through the stellar atmosphere and recovering the velocity field for each atmospheric slice, is an ideal technique for this purpose.

In this colloquium, I will present the tomographic method and its application to spectroscopic and spectro-interferometric observations of giant and supergiant stars as well as to state-of-the-art three-dimensional numerical simulations to constrain their atmospheric motions on spatial and temporal scales and better understand respective mechanisms responsible for their photometric variability and mass loss.

Kateryna Kravchenko

Max Planck Institute for extraterrestrial Physics
Gießenbachstraße 1
85748 Garching bei München, Germany

Phone: +(49) 176 7419 4312
Email: kkravchenko@mpe.mpg.de

Research Experience

Oct 2020 – present **Postdoctoral researcher**
Max Planck Institute for extraterrestrial Physics

- Research: Tomography of evolved star atmospheres, stellar surface imaging using optical long-baseline interferometry, 3D radiative-hydrodynamics simulations of evolved star atmospheres, multidimensional radiative transfer.
- Instrumentation:
  - Installation and commissioning of the VLT/ERIS instrument at Paranal Observatory.
  - Prototyping, assembly, integration, testing, and characterisation of the ELT/MICADO instrument.

Aug 2019 – Sep 2020 **Research Fellow**
European Southern Observatory (Chile)

- Research (50%): Investigating atmospheric dynamics and convection properties in red giant and supergiant stars using the tomographic method developed during the PhD, high-resolution spectroscopic and interferometric observations, and the predictions from 3D radiative-hydrodynamics simulations of stellar atmospheres.
- Observatory duties (50%): support astronomer at the Very Large Telescope Interferometer, VLTI/GRAVITY instrument fellow supporting the GRAVITY Instrument Scientist to optimize the operation of the instrument.

Apr – Jul 2019 **Postdoctoral Researcher**
European Southern Observatory (Germany)

- Data reduction and analysis of VLTI/GRAVITY observations of cool evolved stars in order to measure and compare their variability in the near-continuum and molecular bands.

Mar 2018 – Mar 2019 **ESO Studentship**
European Southern Observatory (Germany)
Supervisors: M. Wittkowski, H.-U. Käufl

- Combining high-resolution spectroscopic VLT/CRIRES and spectro-interferometric VLTI/AMBER observations of Mira-type stars to investigate their shock wave properties.

Feb 2015 – Mar 2019	**PhD Researcher** *Université Libre de Bruxelles (Belgium), Observatoire de la Côte d'Azur (France)* Supervisors: S. Van Eck, A. Chiavassa

- Development of a tomographic method to reconstruct atmospheric motions in stars, validation of this technique on 3D radiative-hydrodynamics simulations of stellar atmospheres, and application to the red supergiant star μ Cep in order to constrain its atmospheric motions and relate them to photometric variability.

  [Link to the PhD thesis]

Mar – Jun 2014	**MSc Internship** *Observatoire de la Côte d'Azur (France)* Supervisor: A. Chiavassa

- Analysis of photometric observations of a transit of the exoplanetary system WASP - 2. Modeling of the transit light curve using synthetic images from 3D radiative-hydrodynamics simulations of stellar granulation showed that the stellar activity influences the derivation of planetary radius and transit duration.

Education

Feb 2015 – Mar 2019	**Ph.D. in Science** Université Libre de Bruxelles (Belgium)
Sep 2013 – Jun 2014	**MSc in Astronomy, cum laude** V.N.Karazin Kharkov National University (Ukraine)
Sep 2009 – Jun 2013	**BSc in Physics, cum laude** V.N.Karazin Kharkov National University (Ukraine)

Instrument Operation & Technical Experience

VLT/ERIS instrument

Oct 2020 – present	Functional and performance testing of the ERIS/SPIFFIER sub-system in the laboratory. Participation in the preliminary acceptance tests (Europe) and Assembly Integration Verification (AIV) of the instrument at the Paranal observatory (Chile).

ELT/MICADO instrument

Oct 2020 – present	Cryogenic testing of prototype mechanisms of the instrument. Design of test setups for performance evaluation of cold optical subsystems of the instrument.

Very Large Telescope Interferometer, Paranal Observatory, Chile

2019 – 2020	Support Astronomer at the VLTI, 80 nights/year

Euler Telescope, La Silla Observatory, Chile

Apr 2019	17 nights of observations with the high-resolution spectrograph CORALIE and the ECAM camera.

APEX Observatory, Chile

Aug 2018	12 nights of observations with heterodyne (PI230, FLASH) and bolometric (LABOCA) instruments.

Mercator Telescope, Roque de los Muchachos Observatory, La Palma, Spain

Apr 2017	10 nights of observations with the high-resolution spectrograph HERMES.

Scholarships and Grants

2019 – present	**ESO Fellowship** European Southern Observatory (Chile)
2018 – 2019	**ESO Studentship** European Southern Observatory (Germany)
2015 – 2018	**The Fund for Scientific Research FNRS/FRIA to work on the PhD research in Belgium**
2013 – 2014	**Scholarship for outstanding students and young scientists in the field of physics and astronomy** V.N.Karazin Kharkov National University (Ukraine)

Skills

Programming	**Python**, **Fortran 77/90**
Pipelines	**esorex, ESO reflex** (AMBER, CRIRES, GRAVITY data reduction)
Languages	**Russian** & **Ukrainian** (native), **English** (professional efficiency), **German** (basic)

Seminars and Talks

Oct 2021	NYRIA (The Network of Young Researchers in Instrumentation for Astronomy) workshop (virtual)
Apr 2021	Invited talk at the DELVE (The Death-throes of EvoLved stars, a Virtual Encounter) conference (Leuven Belgium)
Dec 2019	Evolved stars meeting (Nice, France)
Nov 2019	Seminar at Observatoire de la Cote d'Azur
Nov 2019	MPE seminar (Garching, Germany)
May 2019	Journées 2019 of the French Society of Astronomy & Astrophysics (Nice, France)
Dec 2018	Invited colloquium at the Geneva Observatory (Geneva, Switzerland)
Jun 2018	19th FNRS Contact Group Meeting in Astronomy & Astrophysics (Brussels, Belgium)
Mar 2018	ESO Workshop on Imaging of Stellar Surfaces (Garching, Germany)

Jul 2017	ESO seminar (Garching, Germany)
Jan 2016	Workshop Evolved stars get-together (Gothenburg, Sweden)
Sep 2015	Red Supergiant workshop (Nice, France)

Publications

Submitted Articles

1. Chiavassa, A., **Kravchenko, K.**, Montargés, M., Millour, F., et al. *The extended atmosphere and circumstellar environment of the cool evolved star VX Sagittarii as seen by MATISSE* (accepted by A&A)
2. Prinoth, B., Hoeijmakers, H. J., Kitzmann, D., Sandvik, E., et al. (incl. **Kravchenko, K.**), arXiv:2111.12732: *"Titanium oxide and chemical inhomogeneity in the atmosphere of the exoplanet WASP-189b"* (accepted by Nature Astronomy)

Peer-Reviewed Articles

1. **Kravchenko, K.**, Jorissen, A., Van Eck, S., Merle, T., et al., 2021 A&A, 650, L17, *"Atmosphere of Betelgeuse before and during the Great Dimming event revealed by tomography"*
2. Montargés, M., Cannon, E., Lagadec, E., de Koter, A., et al. (incl. **Kravchenko, K.**), 2021 Nature, 594, 365: *"Imaging Betelgeuse during its Great Dimming"*
3. **Kravchenko, K.**, Wittkowski, M., Jorissen, A., Chiavassa, A., et al., 2020 A&A, 642, A235: *"Tomography of cool giant and supergiant star atmospheres. III. Validation of the method on VLTI/AMBER observations of the Mira star S Ori"*
4. Chiavassa, A., **Kravchenko, K.**, Millour, F., Schaefer, G., et al., 2020 A&A, 640, A23: *"Optical interferometry and Gaia measurement uncertainties revealing the physics of Asymptotic Giant Branch"*
5. **Kravchenko, K.**, Chiavassa, A., Van Eck, S., Jorissen, A., et al, 2019 A&A, 632, A28: *"Tomography of cool giant and supergiant star atmospheres. II. Signature of convection in the atmosphere of the red supergiant star μ Cep"*
6. **Kravchenko, K.**, Van Eck, S., Chiavassa, A., Jorissen, A., et al, 2018 A&A, 610, A29: *"Tomography of cool giant and supergiant star atmospheres. I. Validation of the method"*
7. Paladini, C., Baron, F., Jorissen, A., Le Bouquin, J.-B., et al. (incl. **Kravchenko, K.**), 2018 Nature, 553, 310: *"Large granulation cells on the surface of the giant star π^1 Gruis"*

Other

2021	Referee of Astronomy&Astrophysics
2020	HST Cycle 28 External proposal reviewer
2019	Member of the ESO Paranal Science Operations internship selection committee (ESO Santiago, Chile)
2018	Scientific assistant at the Observing Proposal Committee meeting (Munich, Germany)
2018	LOC at ESO Workshop "Imaging of stellar surfaces" (ESO Garching, Germany)