

# Physics of Extreme Massive Stars

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**Physics of Extreme  
Massive Stars**

Marie-Curie-RISE project  
funded by the European Union



## Outline

- How it began
- Objectives of POEMS
- Marie Skłodowska-Curie Staff Exchange
- Activities within POEMS

# How it began

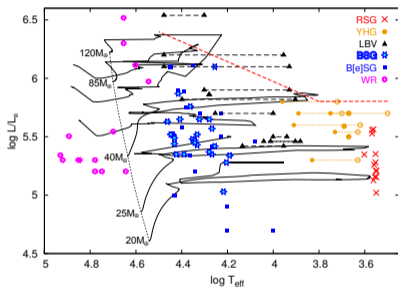


Stellar winds and  
mass loss

Circumstellar  
Environments

Stellar  
pulsations

Influence of  
binarity



Evolutionary  
connections  
(if any)

Mass ejection  
mechanism(s)

Some enthusiastic scientists gathered for a meeting on **Massive Stars in Transition Phases** at Tartu Observatory, September 11-15, 2017, to discuss about most urgent questions in massive star research and to share ideas about how to address them





After 3 days of sharing latest insights in the state of knowledge in the diverse scientific fields, and 2 days of very intense discussions:

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**Let's get funding for a collaboration project !!**

# Then the hard work started....



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.... with coffee and mate consumption increasing daily.

# Objectives of POEMS

- 01** – Deepen our knowledge of stellar winds and wind inhomogeneities, derive comprehensive mass-loss rates for different, non-eruptive phases in massive star evolution, and unravel the potential of slow-wind solutions in forming circumstellar disks.
- 02** – Gain insight into the pulsation habits of various types of evolved massive stars. Quantify the contribution of pulsation-triggered mass loss to the total mass-loss rate, and explore the potential of specific pulsation modes to cause mass eruptions.
- 03** – Achieve comprehension of the chemistry and the physical structure of the material ejected from evolved massive stars.
- 04** – Explore the interaction of stellar winds and ejecta of massive stars with their local ISM and the creation of bow shocks and astrospheres.
- 05** – Unveil the role of binarity for the occurrence of massive stars in extreme phases.
- 06** – Improve our comprehension of stellar evolution of massive stars and unveil evolutionary links between the individual phases of extreme massive stars.

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We need more collaborators!

# Consortium composition

## Germany University of Goettingen

- Stellar pulsations (theory)
- HD modeling
- Numerical simulations
- WR, LBV, YHG, and BSG stars

## Czech Republic Astronomical Institute

- Stellar atmospheres, clumping
- Stellar pulsations (obs)
- (M)HD, astrospheres, winds
- Molecules and dust (theory)
- B[e], YHG, BSG and WR stars
- Optical spectroscopy

## Estonia Tartu University

- Stellar ejecta and light echos
- Stellar pulsations (obs)
- YHG, BSG, Novae stars
- massive binaries
- Optical spectroscopy, imaging, radio observations

## Argentina Universidad Nacional de La Plata

- Stellar atmospheres and winds
- Molecules and dust (obs)
- Stellar pulsations (theory)
- Stellar evolution
- Be, B[e] and BSG stars
- Infrared and radio observations

## United Kingdom University of Leeds

- Circumstellar disks (obs)
- YHG, RSG, B[e], and pre-MS stars
- Spectroastrometry
- Optical interferometry
- Spectropolarimetry

## Belgium Royal Observatory

- Stellar atmospheres and winds
- HD modeling
- Fundamental atomic parameters
- YHG, LBV stars, massive binaries
- Stellar pulsations (obs)
- Imaging and spectroscopy

## Brazil Observatorio Nacional

- Circumstellar material (obs)
- Molecules and dust (theory)
- Be, B[e] and LBV stars
- Massive binaries
- Speckle and optical interferometry
- Spectroscopy and polarimetry

## Chile Universidad de Valparaiso

- Stellar rotation and winds
- HD modeling
- Stellar pulsation (obs)
- Outflowing disk winds
- Be stars, OBA supergiants
- High-cadence spectroscopy

## Chile Pontificia Universidad Catolica de Valparaiso

- Astrostatistics
- Wavelet analysis
- Time-series analysis
- Markov chains Monte Carlo

## Chile Universidad Mayor

- Stellar winds
- Hydrodynamics
- Radiative transfer
- Numerical modeling

## Azerbaijan Shamakhy Astrophysical Observatory

- Massive binaries
- O supergiants
- LBVs, and WR stars
- Optical spectroscopy

# Marie Skłodowska-Curie Staff Exchange

- Focus is on training and knowledge transfer.
- Achieved through secondments of up to 12 months per researcher between involved European and non-European institutes.
- Ideal for PhD-students and post-docs to acquire new knowledge and for improving their skills.
- Additional research money for organizing activities.





# Activities: 2 Summer Schools

International Summer School  
**Stellar Winds and Outflows**  
3.-15. September 2023, Harrachov, Czech Republic

**Main Topics**

- ▶ Winds along stellar evolution
- ▶ Observations of stellar winds
- ▶ Radiative transfer and stellar atmospheres
- ▶ Introduction to (magneto)-hydrodynamics
- ▶ Radiation driven winds of hot stars
- ▶ Introduction to the stellar atmosphere code TLUSTY
- ▶ Introduction to the stellar wind code CMFGEN
- ▶ Winds and outflows from massive pre-main sequence stars
- ▶ Interaction between stellar winds and the ISM
- ▶ Winds and outbursts of evolved massive stars
- ▶ Theoretical treatment of pulsationally driven stellar winds

**Lecturers**

- ▶ Dr. Lydia Cidale (Universidad Nacional de La Plata, Argentina)
- ▶ Dr. Michel Curé (Universidad de Valparaíso, Chile)
- ▶ Dr. Michalis Kourmliotis (Astronomical Institute Ondřejov, Czech Republic)
- ▶ Dr. Michaela Kraus (Astronomical Institute Ondřejov, Czech Republic)
- ▶ Dr. Alex Lobel (Royal Observatory of Belgium, Belgium)
- ▶ Dr. Olga Maryeva (Astronomical Institute Ondřejov, Czech Republic)
- ▶ Dr. Péter Németh (Astronomical Institute Ondřejov, Czech Republic)
- ▶ Dr. Dieter Nickeler (Astronomical Institute Ondřejov, Czech Republic)
- ▶ Dr. René Oudmaijer (University of Leeds, United Kingdom)
- ▶ Dr. Julieta Sánchez Arias (Astronomical Institute Ondřejov, Czech Republic)
- ▶ Dr. Andrea Torres (Universidad Nacional de La Plata, Argentina)

**Additional Information**

- ▶ The school addresses advanced Master and PhD students
- ▶ Lectures will be accompanied by hand-on sessions
- ▶ No registration fee required
- ▶ Registration deadline: July 31

**Logos:** POEMS, Astronomický ústav AV ČR, WOLFRAM, EU

Email: [swo2023@asu.cas.cz](mailto:swo2023@asu.cas.cz) Webpage: <https://stelweb.asu.cas.cz/~kraus/POEMS/SWO/>

VIII LA PLATA INTERNATIONAL SCHOOL

**PULSATIONS ALONG STELLAR EVOLUTION**

NOV 11-22 2019 LA PLATA ARGENTINA

Summer school for PhD students, early-career post-docs and late-stage under-graduate students

No registration fee

**MAIN TOPICS**

- Theory of pulsations, p and g modes, stochastic, solar-type modes (adabats, linear)
- Theory of pulsations, strange modes (non-adiabatic, non-linear)
- Influence of rotation, r modes
- Changes in pulsation behavior along the evolution of low and high-mass stars
- Introduction to different types of pulsating stars on the Hertzsprung-Russell Diagram
- Observational methods: photometric light curves, spectroscopic line profiles, and asteroseismology
- Methods/Techniques to analyse pulsations
- Experiments aimed pulsating stars
- Current and future missions devoted to study stellar pulsations

**Logos:** Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, POEMS, EU

**LECTURERS**

- Dr. Daniel Benvenuto, Universidad Nacional de La Plata, Argentina
- Dr. Daniel Casares, Universidad Nacional de La Plata, Argentina
- Dr. Alejandra Cifuentes, Pontificia Universidad Católica de Valparaíso, Chile
- Dr. Weikang Zhang, Kunming University of Science and Technology, Germany
- Dr. Hristo Iliev, Astronomical Institute Ondřejov, Czech Republic
- Dr. Simon Massey, The University of Sydney, Australia
- Dr. Alejandra Romero, Universidad Federico III de Grande de Sud, Brazil
- Dr. Wojciech Szymański, Universidad de Valparaíso, Chile

APPLICATION DEADLINE: JUNE 28, 2019.

[paase.jp.2019@gmail.com](mailto:paase.jp.2019@gmail.com) <http://paase.fcagp.unlp.edu.ar/>

**Figure:** A plot of  $\log(L/L_{\odot})$  vs.  $\log(\tau)$  showing stellar evolution tracks. A red line indicates a specific path, and a blue line shows a different path. A globe icon is also present.

# Activities: 2 Summer Schools

- Dedicated lectures with exercises and hands-on sessions as well as individual project works.
- Highly motivated and active participation from the students.



# Activities: Final conference



International Conference  
**Physics of Extreme Massive Stars**  
24 – 28 June 2024  
Rio de Janeiro, Brazil



To share the results (and any newly arising open questions) with the astronomical community and to motivate the young generation to continue performing research in physics of extreme massive stars.

I warmly welcome you all  
and wish you a splendid  
and fruitful conference!