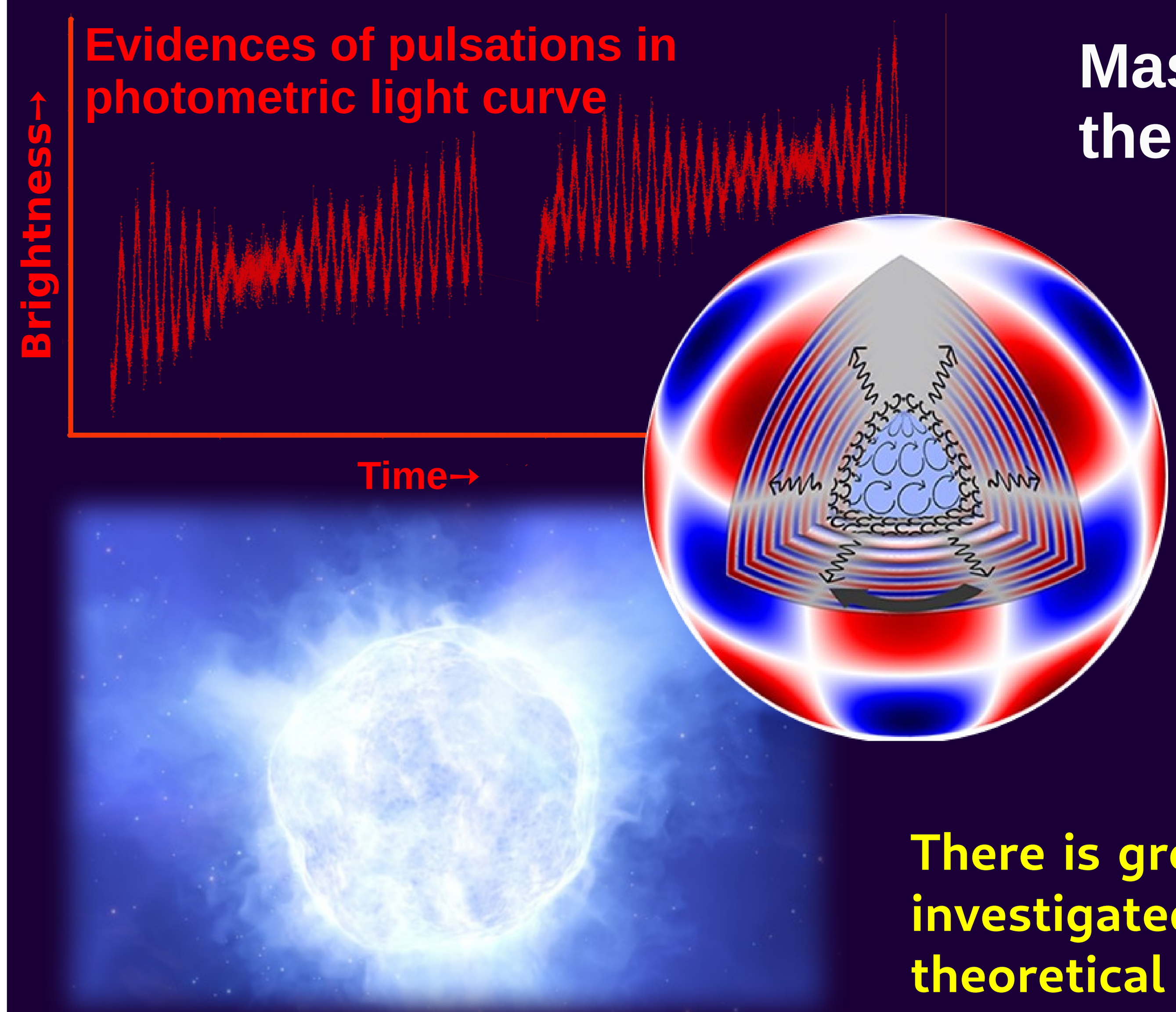
PULSATION-INDUCED MASS LOSS OF BLUE SUPERGIANTS

Massive stars play an important role in many astrophysical processes: from the formation of heavy elements in the Universe to a significant influence on the evolution of their host galaxies and star formation. One of the key parameters required to accurately model these processes, alongside initial mass and rotation, is the **mass loss**. Determining the physics behind the mass loss of **blue supergiants (BSGs)** – an evolutionary phase through which all massive stars pass – is an important pillar of the scientific research carried out at the Stellar Department.



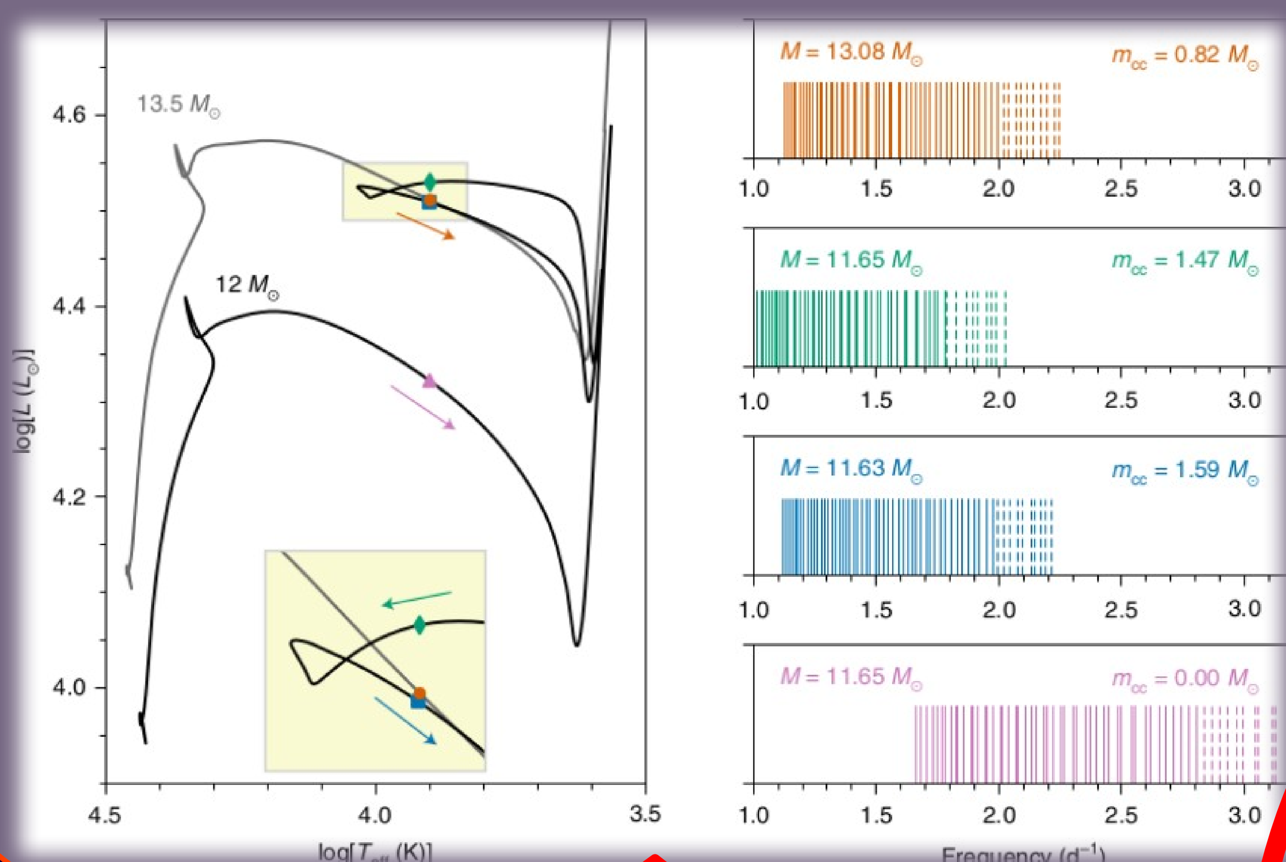
Mass loss is a process during which a star loses part of its mass into the space over time. This can occur through several mechanisms:

- **Stellar winds: continuous outflows of gas driven by radiation pressure or magnetic activity**
- **Pulsation instabilities: pulsations cause expansions and contractions of the star. If the energy of vibrations overcomes the gravitational force, material is lifted from the stellar surface into the space.**
- **Eruptions or outbursts: sudden and episodic releases of mass, especially in massive or unstable stars**
- **Binary interactions: mass transfer to a companion in a binary system**
- **Supernova explosions: for the most massive stars, mass is lost violently in the final explosion**

There is growing evidence that BSGs pulsate, but pulsation-induced mass loss has not been investigated yet in detail. To fill this gap, we carry out detailed combined observational and theoretical studies of the pulsation and mass-loss properties of BSGs. The precise knowledge of how much mass the star loses in this important evolutionary phase has a crucial impact on its final fate as either neutron star or black hole.

Stellar evolution and pulsation models

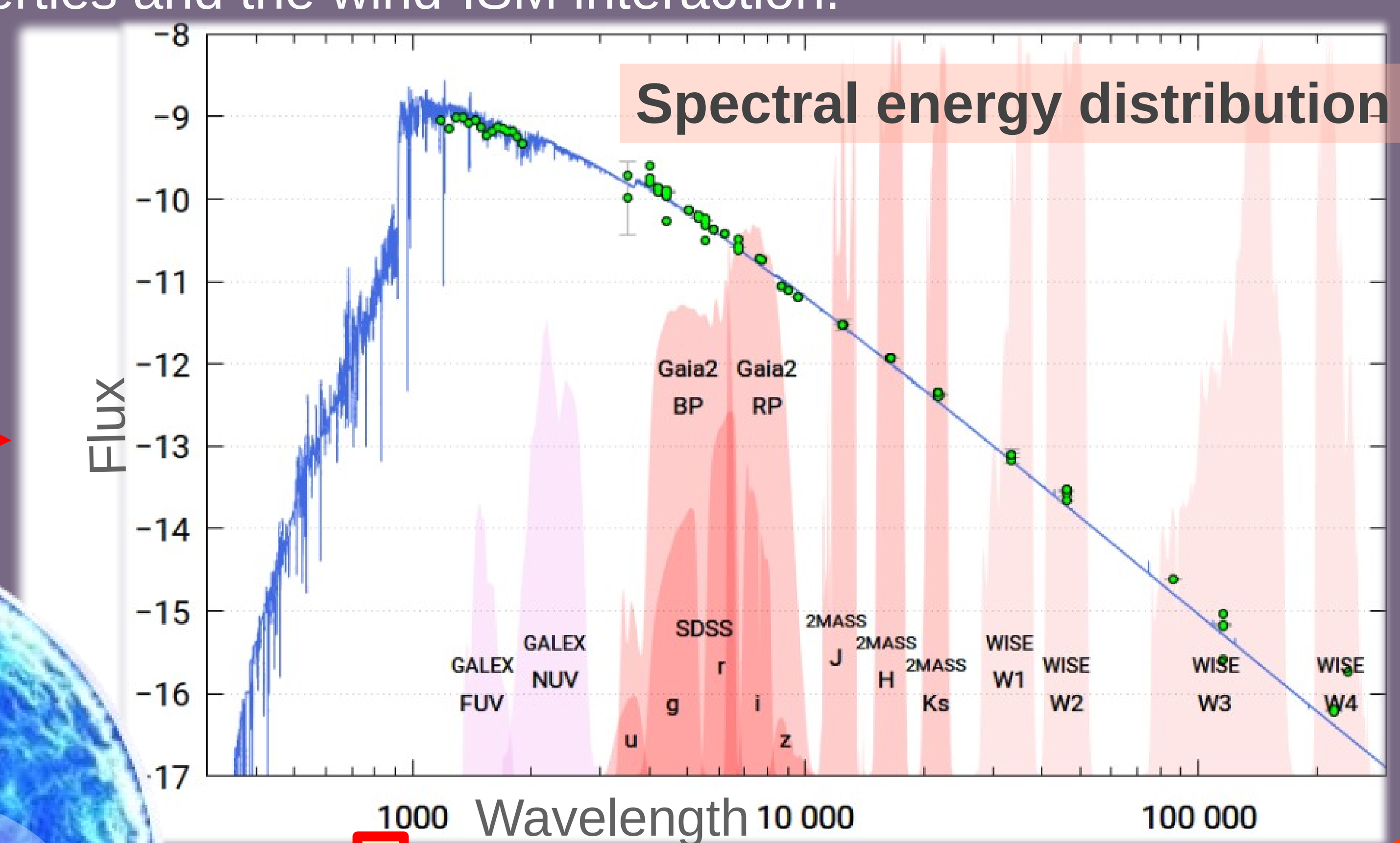
Theoretical models of pulsating stars are computed in two steps. First, a stellar model representing the star's internal structure is created. Then, the excitation of pulsations is calculated to determine the frequency spectrum, which can be compared with observations.

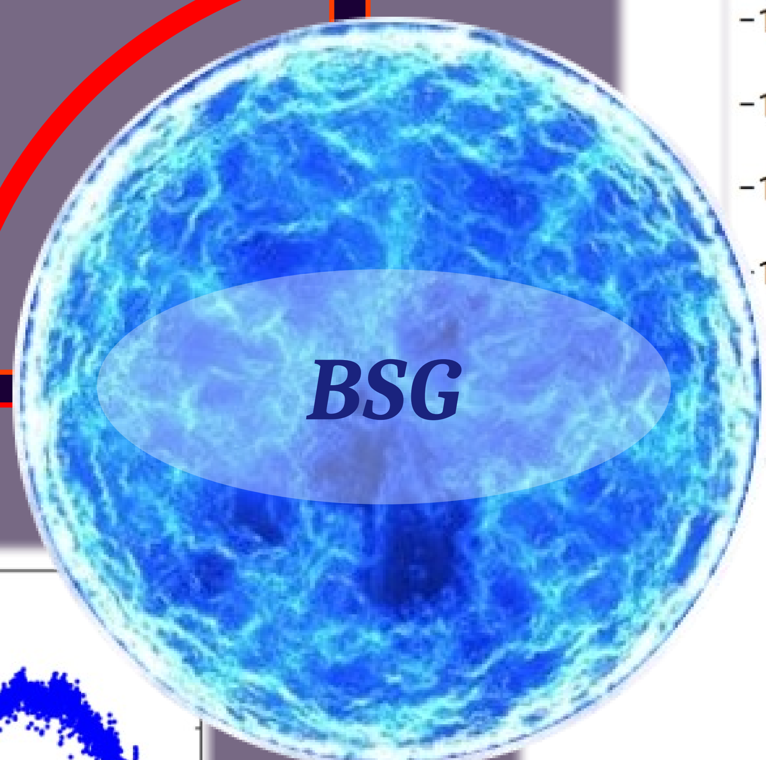


Stellar atmosphere and wind modeling

We develop a large grid of stellar atmosphere and wind models. These are used to refine the stellar parameters and to derive time-dependent wind properties (velocity profile, mass loss) from fitting spectra spreading over the pulsation cycles. The new parameters are used to compute the pulsation properties and the wind-ISM interaction.

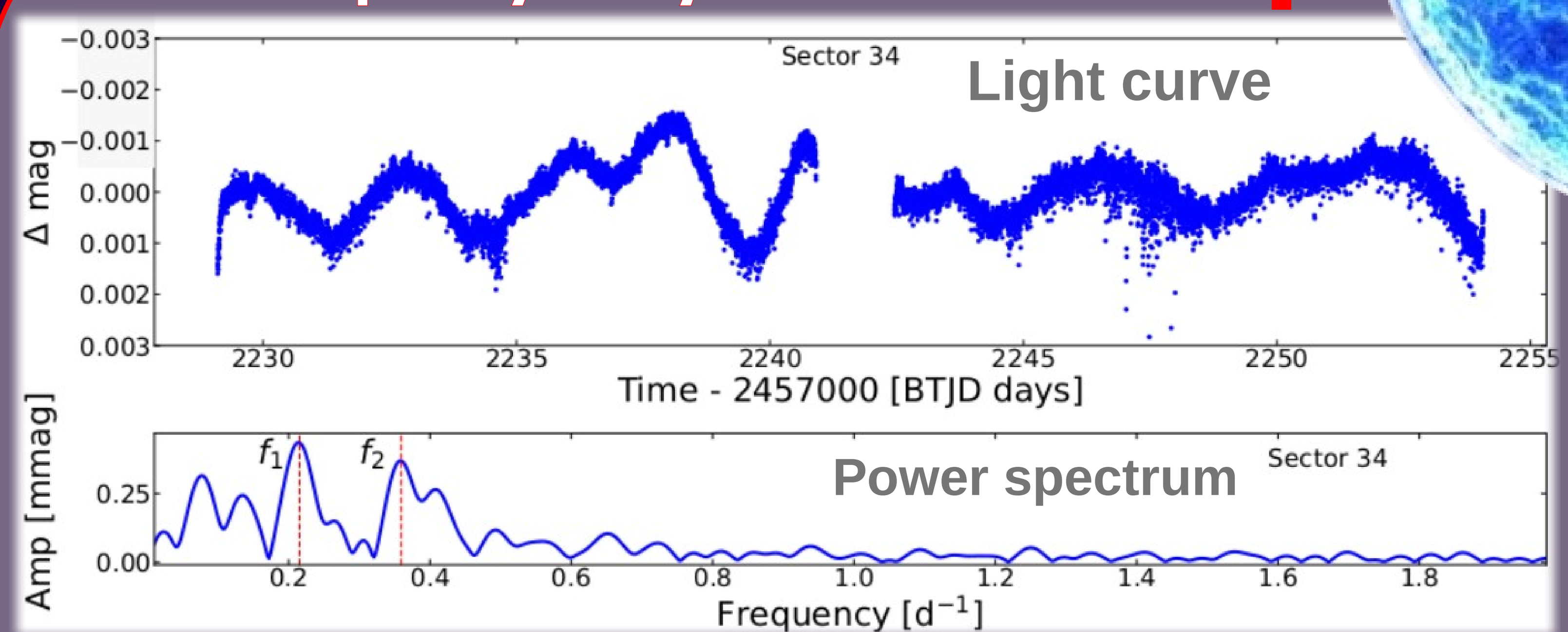
Atmospheric and wind parameters



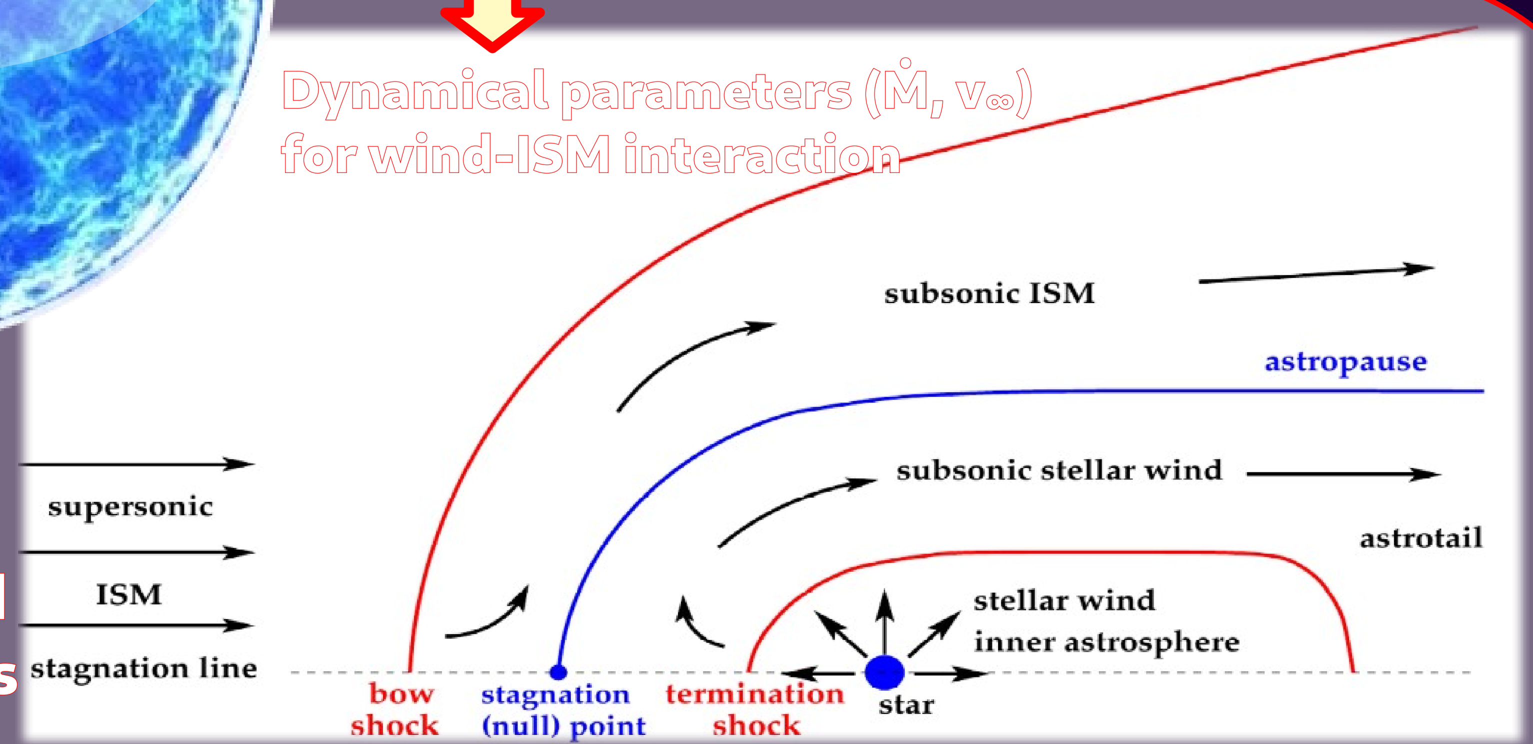


Dynamical parameters ($\dot{M}$, v_∞) for wind-ISM interaction

Frequency analysis of observations



Wind and outbursts



Spectroscopic and photometric time-series

We use multi-wavelength observations to investigate stellar pulsations and wind variability. Spectroscopy provides information on stellar parameters (temperature, mass, chemical composition, rotation) and the atmospheric dynamics (turbulence, pulsations). Photometric light curves reveal brightness variability of objects caused by pulsations, wind inhomogeneities, and outburst activities.

Propagation of wind instabilities and ISM interaction

As stars travel through the interstellar medium (ISM), their wind material interacts with it, creating observable bubble structures known as astrospheres. Time-variable mass loss may contribute to the formation of multiple filaments. Precise knowledge of BSG mass loss aids theoretical studies of bow shock structures.

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