DESCRIPTION FOR THE GENERAL PUBLIC

In stars with masses on the main sequence of torder of 1-8 solar masses (Mo), after exhaustion of hydrogen and helium in their cores, nuclear reactions move to thin layers situated above the nuclei, that are composed mainly of carbon and oxygen. The nucleus is very small (size of the order of the size of the Earth!), while the rest of the star expands to the size comparable to Earth's orbit. This configuration makes the AGB stars lose easily matter from their surface, and mass loss rate is much larger than the rate of hydrogen consumption by nuclear reactions in thin layers situated above the nucleus. As a result, the mass loss rate determines how long star will live during the AGB phase. Despite the efforts still we cannot predict quantitatively what will be mass loss rate for star of given physical and chemical parameters.

Ejected during the AGB material creates a more or less spherically symmetric envelope around the star. The process of intensive mass loss ends when above nucleus, which has a typical mass of 0.6 Mo, remains a matter with mass being a fraction of a percent of the mass of the Sun. We then say that the star has entered a phase of post-AGB. From that moment the star heats up and the moment when it becomes hot enough to start ionization of the ejected matter, marks the formation of a planetary nebula. Surprisingly, the observation with high spatial resolution of post-AGB objects and planetary nebulae showed that their envelope are not generally spherically symmetric! One of the proposed mechanisms responsible for the formation of the observed asymmetry is identified as a well collimated and fast mass ejection, which destroys the symmetry of mass lost during AGB.

Observations of molecular lines (specific fingerprints by which we can identify what molecule is behind a given line) seem to confirm that such a mechanism can take place. Each molecule if it has been excited, emits a photon of a certain energy going back to its lower state. Moreover, these observations allows to determine what was a velocity of the region where such photons were emitted (is nothing but a well-known Doppler effect).

In May 2009, the European Space Agency has sent into space, Herschel Space Observatory, equipped with instruments built by a European consortia with the participation of Poland. The satellite operated until the end of April 2013. Poland contributed to a heterodyne instrument (HIFI), and the P.I. of this project was the Polish coordinator in the consortium Herschel/HIFI. HIFI observed in the sub-millimeter range, which previously was not used for observations. This range is full of fingerprints from different molecules, which carry with them information about the speed of gas from which they were emitted. Thus, observations of molecular lines with high resolution allow studying the mechanism responsible for the destruction of the spherical symmetry in matter ejected during the AGB.

After completion of the Herschel mission, there is still about 40% of no published data, and only a small fraction of the published data have been analysed quantitatively. In our project, in collaboration with scientists from the European Space Astronomy Centre in Spain, where Herschel Archive is located, we not only will reduce in a uniform way all the HIFI data, but also will carry out a quantitative analysis of the most interesting of them. As a result, we will understand better the nature of the physical processes that lead to morphological and chemical changes in the circumstellar envelopes of stars during the late stages of their evolution. Using software to simulate the observations in one dimension we plan to investigate the diversity of the chemical composition of AGB envelopes, while by means of three-dimensional modelling we will analyse the formation of morphological changes in the envelopes of post-AGB objects. Modelling in three dimensions will restore the three-dimensional structure of objects that we see in the sky as two-dimensional structures. Molecular lines will provide information on kinematics of different parts of the modelled objects. The results will be the basis for the preparation of the PhD thesis of one of the co-Investigators of this project. In addition, after completion of the project we intend to provide the uniformly reduced HIFI data to the entire astronomical community, contributing in this way to a heritage of Herchel/HIFI mission.