**Wolf-Rayet Stars**
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# Stellar parameters from photometric data for fainter and more distant Wolf-Rayet stars

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Spectroscopy is the preferred way to study the physical and wind properties of Wolf-Rayet (WR) stars, but with decreasing brightness and increasing distance of the object spectroscopy become very expensive. However, photometry still delivers a high signal to noise ratio. Current and past astronomical surveys and space missions provide large data sets, that can be harvested to discover new WR stars and study them over a wide metallicity range with the help of state of the art stellar atmosphere and evolutionary models.

## 1 Motivation

The large grid of stellar atmosphere models and synthetic spectra (Bestenlehner et al. 2014) has been further extended to higher effective temperatures ($T_{\rm eff}$ from 35 kK to 100 kK) and a wider mass-loss rate range ($\log \dot{M}/(M_{\odot} {\rm yr}^{-1})$ from −6.5 to −3.8). The grid has been computed with the the non-LTE radiative transfer code CMFGEN (Hillier & Miller 1998). For this study I have developed a python code (STellar pARmeterS from pHOTometry, STARSHOT) to extract colours from synthetic spectra using any photometric or self-defined filter system to predict spectral energy distributions (SEDs) and photometric colours of individual stars or stellar populations. These stars or stellar populations can be followed from the formation until the end of their lifetime in combination with evolutionary tracks and stellar initial mass functions.

## 2 Method

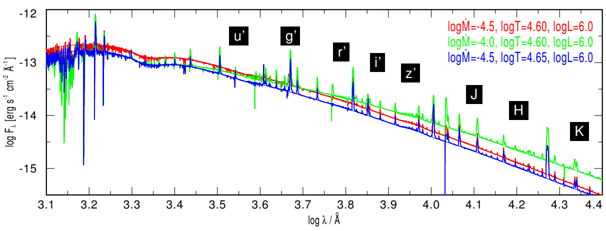


**Fig. 1:** Spectral energy distribution of models with varying $\dot{M}$ and $T_{\rm eff}$. The central wavelengths of SDSS and 2MASS filters are indicated by black boxes.

STARSHOT can be applied to spatially resolved objects as well as unresolved stellar populations such as multiple stellar systems, star clusters and galaxies. Spatially resolved objects are analysed with a grid search approach by applying reddening laws and minimization techniques. Unresolved clusters or galaxies dominated by WR and/or OB star populations are studied with a population synthesis approach by combining synthetic grid spectra, evolutionary models and initial mass functions. Depending on the input of synthetic spectra and evolutionary models it can be applied to any cluster or galaxy.

With this method it is possible to estimate luminosities, helium abundances, effective temperatures and mass-loss rates. The luminosity is derived from the SED by applying the distance modulus and reddening laws. For example for photometry from the Sloan Digital Sky Survey (SDSS), Helium abundances can be derived from the ratio of the g' (He II λ4686) and r' ($H_{\alpha}$) magnitudes. The filters are rather broad and the uncertainties are large. $T_{\rm eff}$ is derived from the slope of the SED. The SED varies stronger in the optical than in the near-IR (Rayleigh-Jeans slope, Fig. 1). The uncertainty increases with increasing temperature and mass loss. $\dot{M}$ has a large impact on the SED in the near-IR in particular for optically thick WR winds (Fig. 1). However, the actual $\dot{M}$ cannot be determined. Only the wind density is derived, which is a function of $\dot{M}$, $v_{\infty}$, clumping and $\beta$-type velocity law.

## 3 Goals

This project is in a very early phase and STARSHOT is extensively developed at the current stage. The goals are: 1) to discover new WR stars based on public available data sets without the need of particular designed narrow band filters, 2) to study their mass loss dependence on the Eddington factor over a wide metallicity range from extremely metal poor to very metal rich in addition what has been found by Bestenlehner et al. (2014) in the Large Magellanic Cloud and Vink & Gräfener (2012) for the Arches Cluster in the Milky-Way, 3) to study the chemical self enrichment of WR stars in relation to the mass-loss time-scale, 4) to analyse the properties of WR and star-burst galaxies. The uncertainties are rather large in comparison to spectroscopic studies, but it can be compensated with a large number statistic.

## References

Bestenlehner, J. M., Gräfener, G., Vink, J. S., et al. 2014, A&A, 570, A38
Hillier, D. J. & Miller, D. L. 1998, ApJ, 496, 407
Vink, J. S. & Gräfener, G. 2012, ApJ, 751, L34