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ABSTRACT

A short summary of this thesis.

ZUSAMMENFASSUNG

Eine kurze Zusammenfassung dieser Arbeit

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LIST OF ABBREVIATIONS

FWHM	Full Width at Half Maximum
IFU	Integral Field Unit
IMF	Initial Mass Function
ISM	Interstellar Medium
LMC	Small Magellanic Cloud
MUSE	Multi-Unit Spectroscopic Explorer
PN	Planetary Nebula
PNLF	Planetary Nebula Luminosity Function
PSF	Point Spread Function
SFE	Star Formation Efficiency
SMC	Large Magellanic Cloud
SN	Supernova
SNR	Supernova Remnant
VLT	Very Large Telescope

1 INTRODUCTION

We revisit a paper by Kreckel et al. (2017). In this paper we use data from the *Multi-Unit Spectroscopic Explorer* (MUSE) instrument of the *Very Large Telescope* (VLT) to identify *planetary nebula* (PN) and use the *planetary nebula luminosity function* (PNLF) to measure their distance. PNe are a reliable distance measure

PHOTOMETRY 2

2.1 GROWTH CURVE ANALYSIS

2.1.1 *Gaussian*

A shape that is commonly used for the PSF is that of a 2D gaussian (we assume variance of $\sigma_x^2 = \sigma_y^2 = \sigma^2$). If we center the peak at the origin the *point spread function* (PSF) is described by

$$f(x,y) = A\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \tag{1}$$

with some amplitude A. We can rewrite this in polar coordinates as

$$f(r,\phi) = A\exp\left(-\frac{r^2}{2\sigma^2}\right) \tag{2}$$

The light inside an aperture of radius $P(R)$ is given by the integral

$$P(R) = \int_0^{2\pi}\int_0^R f(r,\phi)\mathrm{d}\phi r\mathrm{d}r = 2\pi\sigma^2 A\left(1-\exp\left(-\frac{R^2}{2\sigma^2}\right)\right) \tag{3}$$

We are interested in the ratio $p(R) = P(R)/P(\infty)$. If we use the relation between the standard deviation and the FWHM of a Gaussian $\mathrm{FWHM} = \sigma 2\sqrt{2\ln 2}$, we can write

$$p(R) = 1-\exp\left(-\frac{4\ln 2\cdot R^2}{\mathrm{FWHM}^2}\right) \tag{4}$$

2.1.2 *Moffat*

The measured FWHM are systematically larger than the reported values. A possible cause is that the shape of the PSF is not a perfect Gaussian, but rather described by a Moffat. This distribution is larger towards the wings and fitting a Gaussian to such a shape should result in a larger FWHM

$$f(R;\alpha,\gamma) = A\left[1+\left(\frac{R}{\gamma}\right)^2\right]^{-\alpha} \tag{5}$$

Note: this nomenclature follows ‘astropy‘ and contradicts the commonly used scheme which uses $\gamma = \alpha$ and $\alpha = \beta$.

The Full Width Half Maximum of this function is given by

$$\mathrm{FWHM} = 2\gamma\sqrt{2^{1/\alpha}-1} \tag{6}$$

like we did for the Gaussian we can calculate the amount of flux within a radius R as

$$P(R) = \int_0^{2\pi}\int_0^R f(r,\phi)\mathrm{d}\phi r\mathrm{d}r = 2\pi\int_0^R A\left[1+\left(\frac{r}{\gamma}\right)^2\right]^{-\alpha} r\mathrm{d}r \tag{7}$$

to solve this we substitute $u = 1+\left(\frac{r}{\gamma}\right)^2$ with $\frac{\mathrm{d}u}{\mathrm{d}r} = \frac{2r}{\gamma^2}$.

$$P(R) = A\frac{\gamma^2\left(1+\left(\frac{R}{\gamma}\right)^2\right)}{2(1-\alpha)\left(1+\left(\frac{R}{\gamma}\right)^2\right)^{\alpha}} - A\frac{\gamma^2}{2(1-\alpha)} \tag{8}$$

again we are interested in the ratio $p(R) = P(R)/P(\infty)$. If we assume that $\alpha > 1$, the first term will be 0 for $R \to \infty$ and so we end up with

$$p(r) = \left[1+\left(\frac{R}{\gamma}\right)^2\right]^{1-\alpha} - 1 \tag{9}$$

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