

# Slowly-rotating nitrogen-rich O stars in 30 Doradus

F. Tramper 

Institute of Astronomy, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium  
email: [frank.tramper@kuleuven.be](mailto:frank.tramper@kuleuven.be)

**Abstract.** The VLT/FLAMES Tarantula Survey (Evans et al. 2011) identified a group of slowly-rotating nitrogen-rich O-type stars that cannot be explained by current evolutionary models. Here we present high-quality VLT/UVES observations of four of these stars that allow a detailed quantitative spectroscopic analysis. We present the analysis of the spectra with a genetic algorithm, and discuss the future steps to be taken to further investigate the cause of the nitrogen enrichment.

**Keywords.** stars: abundances, stars: atmospheres, stars: chemically peculiar, stars: early-type, stars: evolution, stars: fundamental parameters

---

## 1. Introduction

Rotation is a key element affecting the evolution of massive stars. High rotation rates allow the mixing of material between the core and the envelope. As a consequence, more hydrogen becomes available in the core resulting in significantly longer main-sequence lifetimes (up to 30%, e.g., [Brott et al. 2011](#)). Simultaneously, CNO processed material is mixed into the envelope, increasing the nitrogen and decreasing the carbon and oxygen surface abundances. While the current generation of evolutionary models differ in the amount of mixing predicted and the rotation rate needed to have a significant impact on massive star evolution, they do agree on two important observational effects:

- (1) a strong correlation between surface nitrogen abundance and rotation rate, and
- (2) the almost complete absence of nitrogen enrichment for slowly-rotating massive stars.

Contrary to these predictions, [Hunter et al. \(2008\)](#) found a group of slowly-rotating nitrogen-rich B-type stars in the framework of the VLT-Flames Survey of Massive Stars ([Evans et al. 2006](#)). More recently, a similar group of O-type stars has been found in 30 Doradus (aka the Tarantula nebula) by [Grin et al. \(2017\)](#) in the VLT-Flames Tarantula Survey ([Evans et al. 2011](#)).

## 2. Analysis

To investigate the nature of the slowly-rotating nitrogen-rich stars in 30 Doradus we obtained high-quality ( $R \sim 40000$ ,  $S/N > 100$ ) spectra of four representative stars using VLT/UVES. These spectra allow the accurate derivation of the key stellar parameters and the surface abundances of helium, carbon, nitrogen, oxygen, and silicon. The spectra were analysed by fitting synthetic spectra from the model atmosphere code FASTWIND ([Puls et al. 2005](#)) using a genetic algorithm (GA, Fig. 1). This method allows us to



**References**

- Brott, I., de Mink, S. E., Cantiello, M., et al. 2011, *A&A*, 530, A115
- Evans, C. J., Lennon, D. J., Smartt, S. J., et al. 2006, *A&A*, 456, 623
- Evans, C. J., Taylor, W. D., Hénault-Brunet, V., et al. 2011, *A&A*, 530, A108
- Grin, N. J., Ramírez-Agudelo, O. H., de Koter, A., et al. 2017, *A&A*, 600, A82
- Hunter, I., Brott, I., Lennon, D. J., et al. 2008, *ApJ* (Letters), 676, L29
- Mokiem, M. R., de Koter, A., Puls, J., et al. 2005, *A&A*, 441, 711
- Puls, J., Urbaneja, M. A., Venero, R., et al. 2005, *A&A*, 435, 669
- Tramper, F., Sana, H., de Koter, A., et al. 2011, *ApJ* (Letters), 741, L8
- Tramper, F., Sana, H., de Koter, A., et al. 2014, *A&A*, 572, A36