WAVELET ANALYSIS OF VARIABLE WOLF-RAYET EMISSION LINES.

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A new powerful mathematical tool for the analysis of structures on spectral lines is presented: wavelet analysis. Applied to variable Wolf-Rayet emission lines, it allows one to extract efficiently and in an objective way, individual sub-structures and compare some of their physical properties: integrated flux f, velocity dispersion σ_v, projected velocity v and acceleration a.

The wavelet transform of a signal $I(v)$ is the convolution of that signal with a function $\psi(v)$ called a *wavelet*, which is *localised* and defined by two parameters: location v_c and width σ_v (Farge 1992; Daubechies 1993). It is analogous to a Fourier transform. However, while Fourier transforms always lose information about position, this information (v_c) is preserved in the wavelet transform, as well as the spatial frequency σ_v (*e.g.*, Fig. 1). The wavelet transform acts as a filter, separating components having different widths. It is well-suited for 'multi-scale' analysis, because it can focus on a particular scale. By comparing the typical intensity associated with a given scale (Fig. 2), one can evaluate the nature of the different structures composing a signal. The wavelet transform can also be used as a structure identifier. It allows one to separate and extract individual emission features seen on top of WR emission lines (*cf.* Moffat *et al.* 1993; Lépine 1994).

The technique has so far been applied with success to data from seven WR stars of different subclasses, taken from Robert (1992). Sets of structures were identified and their physical properties compared. Many relations emerge, which are similar for each star, including:

1. $f \sim \sigma_v^2$ (*e.g.*, Fig. 3), indicating that brighter structures have a larger velocity dispersion, which can therefore be associated with their spatial extension.
2. σ_v is correlated with v_c (Fig. 4), revealing some anisotropy for the velocity dispersion of the substructures in the wind (remember that v_c is the projected velocity $\sim v_{inf} cos\theta$, where θ is the projection angle). The velocity dispertion is larger in the *radial* direction; this suggest that radiative processes are involved.

These are compatible but much improved compared to the previous work by Robert (1992), based on a multi-gaussian decomposition technique instead of wavelets.

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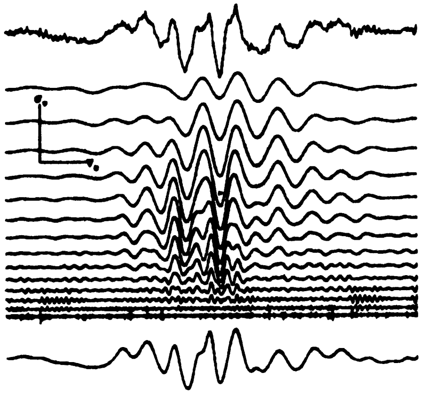

Fig. 1. Wavelet transforms, in (v_c, σ_v) space, of differences from the mean spectrum for the WR137 (WC7+O?) CIII 5696Å line (top). Notice the filtering effect separating large and small scales. The bottom signal is a reconstruction from the largest discrete structures identified

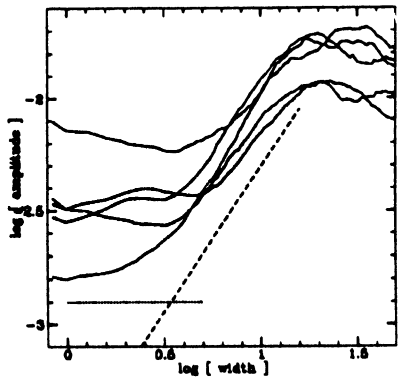

Fig. 2. Typical structure intensity as a function of the velocity dispersion (width) deduced from the wavelet transform for each star. Dotted and dashed lines show the expected profile for noise and for a power law distribution, respectively. Star profiles show a combination of both

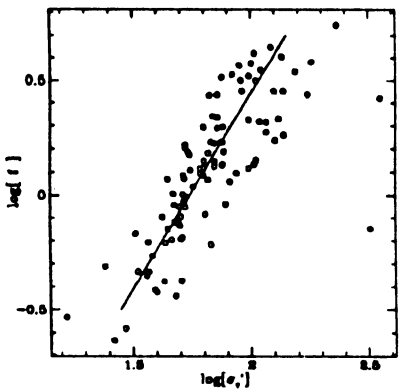

Fig. 3. Relation between flux and velocity dispersion of the variable features in the CIII line of WR140 (WC7+O4)

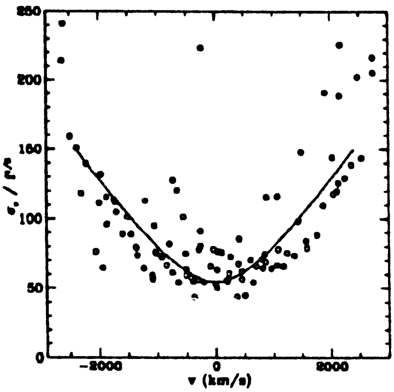

Fig. 4. Velocity dispersion as a function of projected velocity of the variable features in the CIII line of WR140 (WC7+O4).

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