Can we improve spectral disentangling methods?

Philippe Eenens[1] and Edwin Quintero[2]

[1]Guanajuato, Mexico

[2]Pereira, Colombia

TOC of this presentation

Introduction

In the observed spectra of binary stars
the lines are never completely deblended
if:

- the orbital movement is slow (long periods) and
- the lines are broad (massive stars with winds or fast rotators).

Introduction

In such cases a disentangling method is helpful

- to obtain the individual spectra of each stellar components:
  $\rightarrow$ to determine their spectral types;
  $\rightarrow$ to study their chemical composition and temperature;
- to improve the determination of the orbit.

The 'shift and add' method

Many disentangling efforts are based on this iterative algorithm.

1. Correct for Doppler shift of star A, then add.
   $\Longrightarrow$ The A spectrum dominates, B is diluted.
2. Subtract this first approximation of A to each spectrum of B.
   $\Longrightarrow$ B only (as a first approximation).
3. Subtract this new spectrum of B to each spectrum of A.
   $\Longrightarrow$ Etc.

Marchenko, Moffat & Eenens 1998, PASP 110, 1416

Shift and add

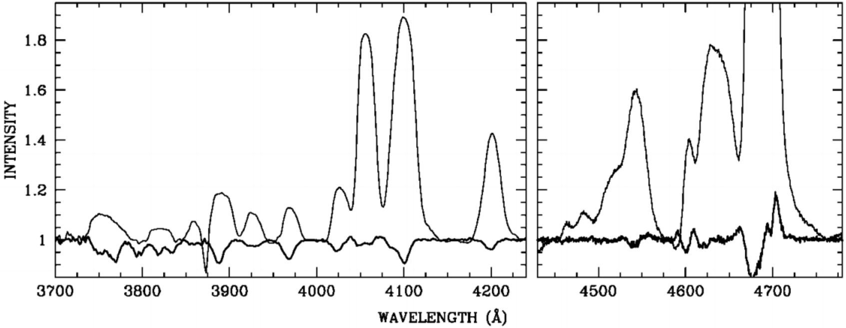


FIG. 1.—Restored spectra of the WR and O components of WR 141. See text for details.

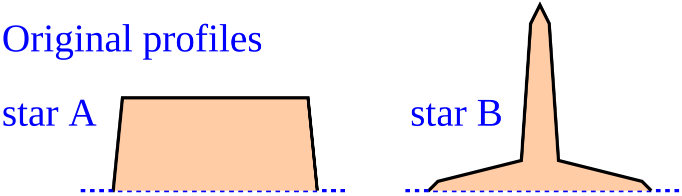
Shift and add

How do we know that the reconstructed profile is a faithful representation of the original stellar profile?

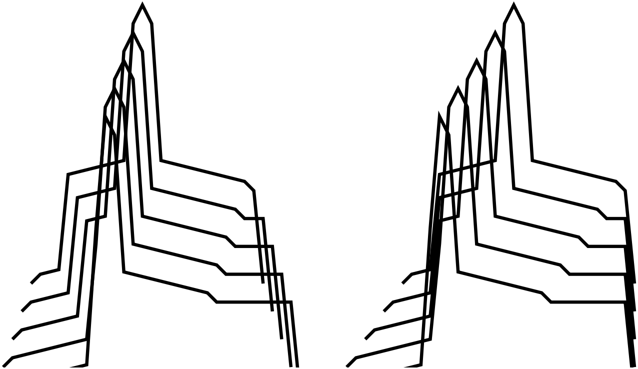
To analize the behaviour of this algorihtm:

- we will start with synthetic profiles
  $\longrightarrow$ so we can compare it and the reconstructed profile.
- We will use very distinctive shapes,
  $\longrightarrow$ so any difference is easy to interpret.

Shift and add



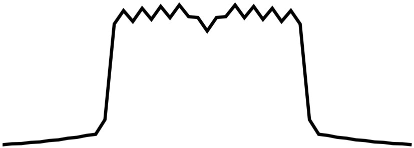
Shift and add



Blends at five phases ... shifted and centered on star A

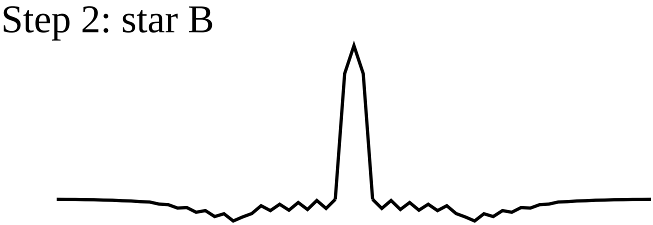
Shift and add

Step 1: star A



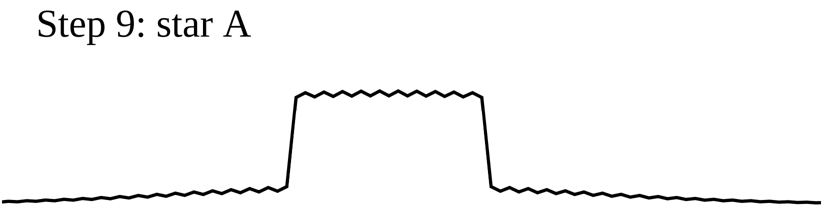
Ten blends, shifted around star A, have been coadded.
Star B is 'diluted'.
This gives a first approximation of star A.

Shift and add



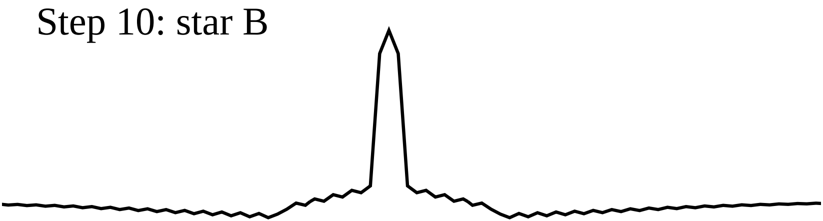
This approximation of star A is then subtracted from the blends to yield star B.

Shift and add



After five iterations, we obtain a good reconstruction of star A.

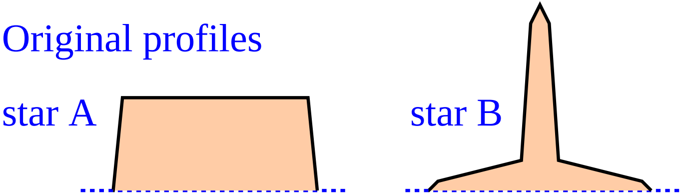
Shift and add



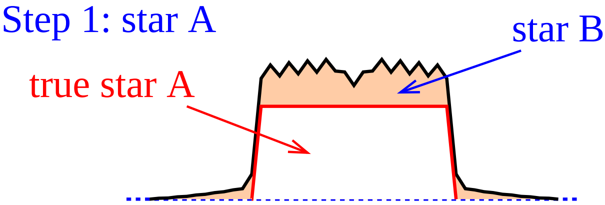
... and of star B.

Problems?

As we have access to the original profiles,
we can compare our reconstructed profiles with these:

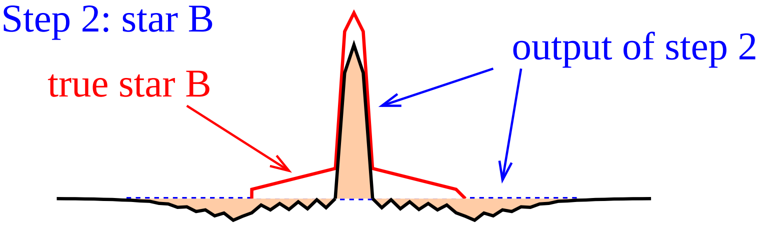


The problem



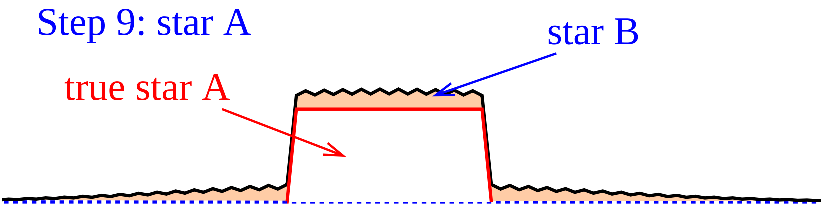
Although diluted over a range of wavelengths,
all the flux from star B has been added to star A.

The problem



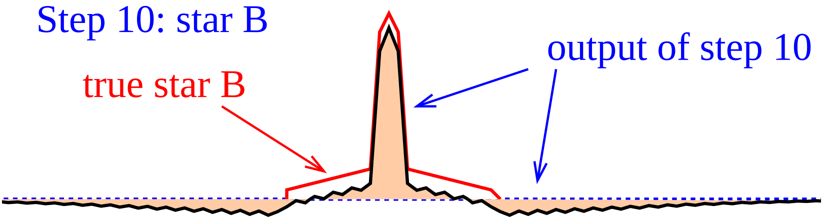
... and subtracted from star B.

The problem



At the end, most of the flux from star B
is creating spurious wings of star A.

The problem



In the reconstruction of star B, the total flux is zero.
The continuum has been shifted.

The problem

1. The fluxes are not correct.
   - The reconstructed spectrum A contains the fluxes from both stars.
   - The continuum is too low in star B.

   Fluxes are important to determine:

   - the spectral type of the components of the binaries;
   - abundances in the wind and its ionization.
2. Spurious wings have appeared in the spectrum of star A.

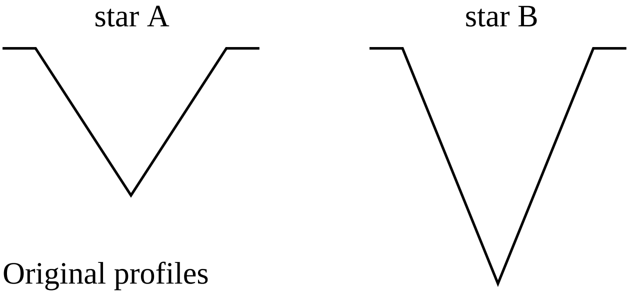
   Wings are used to characterize the mass loss.

Toward a solution

Let us make the effects worse:

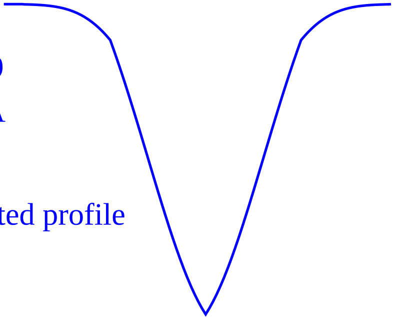
- with the flux in the spectral line of star B stronger than in A;
- with very small Doppler shifts (5) compared to the FWZI (100).

Toward a solution



Original profiles

Toward a solution

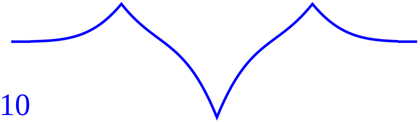


step 9

star A

Reconstructed profile

Toward a solution

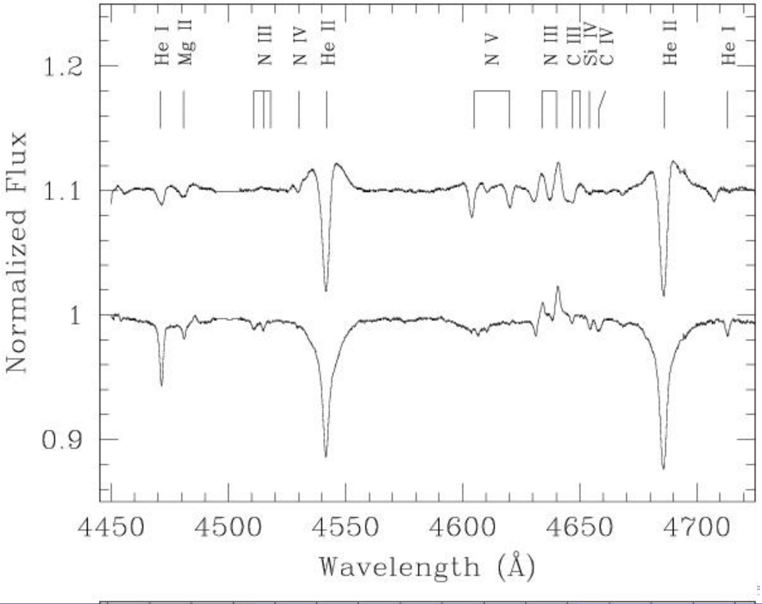


step 10

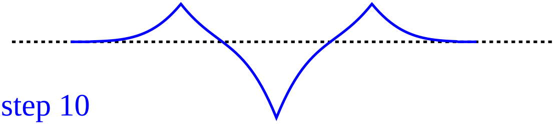
star B

Reconstructed profile

9 Sgr


He I
Mg II
N III
N IV
He II
N V
N III
C III
Si IV
C IV
He II
He I
1.2
1.1
1
0.9
Normalized Flux
4450
4500
4550
4600
4650
4700
Wavelength (Å)

Toward a solution

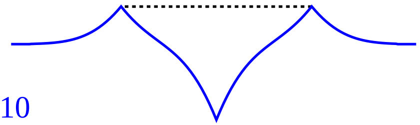


step 10

star B

Reconstructed profile

Toward a solution

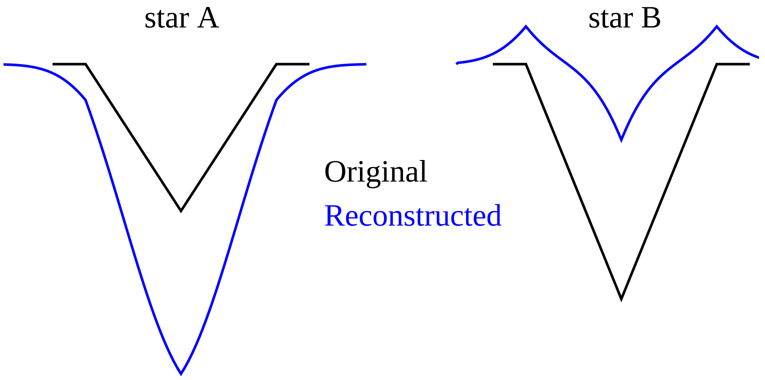


step 10

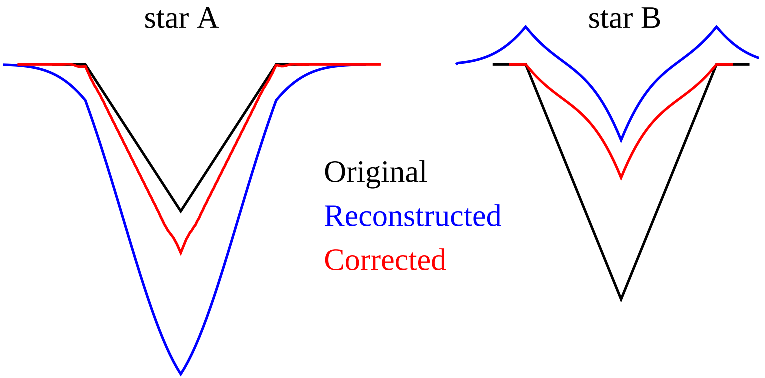
star B

Reconstructed profile

Toward a solution



Toward a solution



Future work

- Asymmetric profiles
- Varying profiles
- Hide-and-seek algorithm