The mass of the very massive binary WR21a

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SUMMARY AND CONCLUSIONS

- massive binary systemである**WR21a**
- 2011年の近星点を含むmulti-epoch spectroscopic observation via VLT/X-Shooter
- minimum mass
  -- M1 $\sin^3 i$ = 64.4 +/- 4.8 M⊙
  -- M2 $\sin^3 i$ = 36.3 +/- 1.7 M⊙
- 分離した個々のSpectral type
  -- O3/WN5ha (primary)
  -- O3Vz ((f*)) (secondary)
- from spectral type of M2
  -- absolute mass of M2 = 58.3 +/- 3.7 M⊙
  -- i = 58.8 +/- 2.5 degree
  -- M1 = 103.6 +/- 10.2 M⊙
- age : 1.5 Myr
- total mass : M_total = 161.9 +/- 19.0 M⊙
- system luminosity : log(L/L⊙) = 6.38 @ 8kpc

2. OBSERVATIONS

- X-Shooter spectrograph with VLT
- exposure time = 90s
- slit = 0.5 arcsec
- UBV 3000-5500A, R=9900
- VIS 5500-10000A, R=18200
- NIR 10000-25000A, R=10500

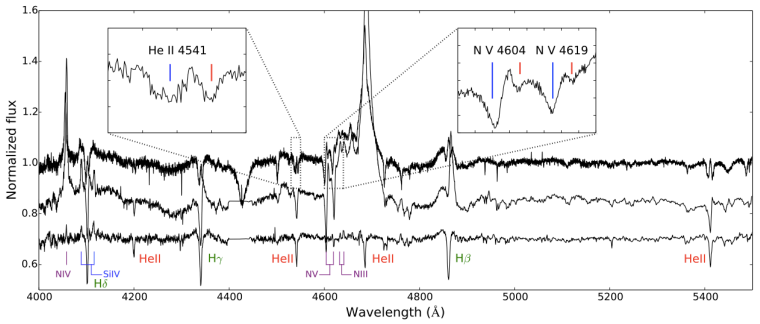

Figure 1. Rectified X-Shooter UVB spectrum of WR21a at epoch 16 (top spectrum), and the disentangled spectra of the primary and secondary components (middle and bottom spectra, respectively, and both displaced from unity for clarity). The insets show two of the SB2 lines used for the RV measurements, in which the redshifted contribution of the primary is indicated by the blue line and the blueshifted contribution of the secondary in red.

3. ORBITAL PROPERTIES

- 方法
  1. 個々のスペクトルラインに対して、one or two Gaussian functionでフィット。
  2. 2つのGaussian fitを２つのコンポーネントにフィッティング。
  3. すべてのepochに適応。
- 軌道フェイズφ～0.6-0.7を除いては、ラインプロファイルの大きな変化は見られない。
  ----> ラインプロファイルはフィックスしてもよい。

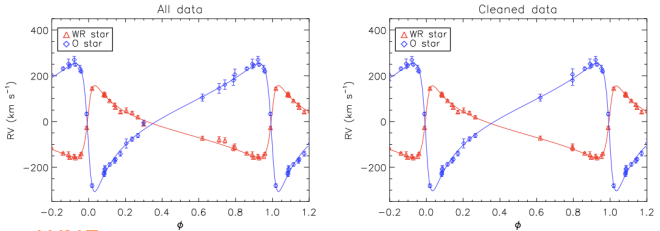

Figure 3. Best-fitted orbital solutions obtained with all data (left) and with poor RV measurements removed (right).

Table 1. Best-fitted orbital solutions.

Parameter	Units	All data WR	All data O	Cleaned WR	Cleaned O
P	(d)	31.680 ± 0.013		31.672 ± 0.011	
e		0.694 ± 0.005		0.6949 ± 0.0047	
M_1/M_2		1.782 ± 0.030		1.776 ± 0.025	
T	−2450 000	6345.43 ± 0.32		6345.20 ± 0.28	
ω	(°)	287.8 ± 1.2		287.2 ± 1.1	
K	(km s^{-1})	157.0 ± 2.3	279.8 ± 6.2	156.9 ± 2.0	278.6 ± 5.3
γ	(km s^{-1})	−32.8 ± 1.7	32.8 ± 2.9	−32.5 ± 1.6	32.0 ± 2.7
$M \sin^3 i$	($M_\odot$)	65.3 ± 5.6	36.6 ± 1.9	64.4 ± 4.8	36.3 ± 1.7
rms	(km s^{-1})	8.44		6.98	
$\delta\gamma$(He II λ4200)	(km s^{-1})	5.1 ± 4.0		4.8 ± 4.1	
$\delta\gamma$(He II λ5412)	(km s^{-1})	−6.0 ± 2.6		−5.7 ± 2.7	
$\delta\gamma$(N IV λ4058)	(km s^{-1})	−5.2 ± 2.5		−5.9 ± 2.6	
$\delta\gamma$(N IV λ4058)	(km s^{-1})	19.2 ± 2.4		19.8 ± 2.5	

4. DISCUSSION

4.1 Spectral types
- primary star
  -- hydrogenが見えるので、WNh。
  -- NIII4634-41があって、NIII5314が吸収線で見える -----> WN5
  -- HeII & NV吸収線 ----> suffix 'a'
  -- Strong NV absorption ----> transition ('slash' star)
  ----> O3/WN5ha (cf : ~O2.5If*/WN6ha)
- Secondary
  -- no sign of HeI, NV4604-4619 absorption line ----> O4よりearly
  -- NIII emission line ----> O2, O2.5は除外
  -- NIII, NIV, NVの相対強度比 ----> O3
  -- HeII4200 & 4541 ----> Vz luminosity class
  -- 他に、NIV4058, SiIV4089, 4116, weak NIII4634-41も。
  -- HeII 4686はcolliding windに影響されるので、もしかしたらO2は怪しいかも。
  ----> O3Vz((f*))
  -- mass estimation by Martin, Schaerer & Hillier (2005)
  ----> secondary mass = 58.3 +/- 3.7 M⊙
  ----> inclination : i = 58.8 +/- 2.5 degree
  ----> primary mass = 103.6 +/- 10.2 M⊙

4.2 Absolute mass estimates
- 図4 : mass-luminosity relation
  -- primary mass range : 70-115 M⊙ (5Msloar step)
  -- 2ndary massはtable 1にあるような比で（100:56）
  -- 距離を6-8kpcとすると
  ----> total mass = 130-200 M⊙ for ZAMS system
  ----> total mass = 110-170 M⊙ for 1.5Myr
  -- 2ndaryのスペクトルタイプ（から得られるmass）で考えると、
  ----> total mass = 161.9 +/- 19 M⊙ @ 8kpc for 1.5Myr