Universidad de Valparaíso CHILE

MASSIVE STARS GROUP
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Recuperando la Tabla de Abbott

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Solución analítica de los vientos impulsados por radiación.

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The Astrophysical Journal, **259**:282–301, 1982 August 1

THE THEORY OF RADIATIVELY DRIVEN STELLAR WINDS.
II. THE LINE ACCELERATION

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Received 1981 December 10; accepted 1982 February 19

ABSTRACT

Numerical values of the radiation pressure on spectral lines are presented for the envelopes of stars with spectral type O–G, and with any luminosity, metallicity, or velocity structure. The line acceleration was calculated using a tabulation of atomic lines that is complete for the elements H–Zn. The line acceleration is remarkably constant over the temperature range $50{,}000 \geq T_{\rm eff} \geq 10{,}000$ K, but drops off sharply for cooler stars. The anomalous ionization observed in OB stars decreases the acceleration by up to a factor of 2 from radiative equilibrium values. More than one-half of the acceleration comes from lines whose frequencies overlap with those of neighboring lines at some point in the wind. Line blanketing of the continuum flux by the wind becomes significant for mass loss rates exceeding $\sim 10^{-6}\ M_\odot\ {\rm yr}^{-1}$.

The predicted and observed mass loss rates are in complete agreement for the OB stars, and we conclude that radiation pressure is the dominant mechanism driving the winds from these stars. The mass loss rates of Wolf-Rayet stars are not explained by these models, even accounting for the effects of chemical enrichment on the line acceleration. Radiation-driven mass loss is still significant in F and G supergiants, but the predicted rates are smaller than for OBA supergiants of comparable luminosity. The predicted mass loss rate scales nearly linearly with metallicity, with obvious consequences for stellar systems formed in regions of very high, or very low, metallicity.

Subject headings: stars: early-type — stars: mass loss — stars: supergiants — stars: winds — stars: Wolf-Rayet

I. INTRODUCTION

Stellar winds are observed in O-type stars, A and B supergiants, Wolf-Rayet stars, and the central stars of planetary nebulae (e.g., Conti 1978). These stars are all hot and highly luminous for their mass, which led to the development of a radiation-driven wind theory to explain the mass loss (e.g., Cassinelli 1979). In this model, momentum is transferred from the radiation field to the gas by scattering of radiation in spectral lines. The realism of these models is therefore limited primarily by the accuracy of the calculated line acceleration.

The first modern-day calculation of the radiation force was by Lucy and Solomon (1970), who demonstrated that line scattering in OB stars is so efficient that the radiative momentum absorbed by a single, strong line can overcome gravity. Castor, Abbott, and Klein (1975, hereafter CAK) showed that the acceleration by many weaker lines is a factor of 100 greater than that from the few, strong resonance lines considered by Lucy and Solomon. CAK estimated the line acceleration from all heavy elements using a complete line list for the C III ion. More elaborate calculations by Castor, Abbott, and Klein (1976), as well as Lamers and Morton (1976), confirmed that the line acceleration results from the contribution from a large number of lines and many different elements, many with wavelengths in the Lyman continuum where they cannot be observed.

It has yet to be shown by a quantitative calculation, however, that there are sufficient lines to drive the mass loss observed from these stars. In addition, the dependence of the line acceleration on temperature, density, and chemical composition is needed to compare theory to the wide variety of stars now observed to have winds. This is the motivation for the present paper, which gives improved numerical calculations of the line acceleration in expanding atmospheres of hot stars. Values of the acceleration are tabulated for a sufficiently broad range of effective temperatures, densities, and elemental abundances so that stellar wind models can be generated from this data using the hydrodynamic equations discussed in Paper I (Abbott 1980). Examples of such wind models will be given in Paper III of this series.

To properly calculate the line acceleration, one must solve the radiative transfer problem and tabulate the line opacity. The major improvement of these calculations over previous work is the line opacity, which was computed using a list of atomic lines and *gf*-values that is essentially complete for the first to sixth stages of ionization of the elements H–Zn. Section II describes the atomic data and the method used to calculate the acceleration.

The resulting line acceleration is given in § III. The acceleration is remarkably insensitive to temperature, depends weakly on density, and increases with metallicity. We also estimate bounds on the uncertainty in the acceleration because of the effects of overlapping lines and the effects of anomalous ionization in the wind.

282

Códigos Usados

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HYDWIND

Código que calcula la hidrodinámica del viento a partir de la resolución de la ecuación analítica. Devuelve parámetros **$\dot{M}$, V_∞ y el perfil de velocidad.**

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PAKD27

Código que a partir de la entrega de $\dot{M}$, V_∞ y la hidrodinámica, obtiene cálculos numéricos del Force Multiplier (lo cual es usado para **ajustar α y k**)

MÉTODO USADO

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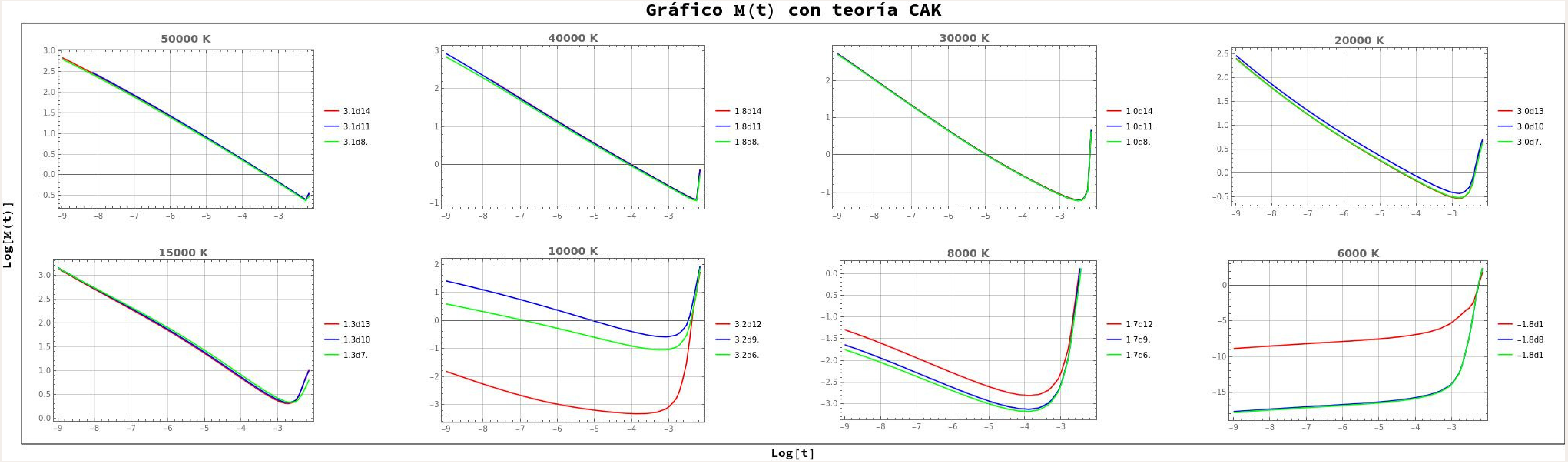
RESULTADOS PRELIMINARES



RESULTADOS PRELIMINARES

Tabla con k y α para cada Ne/W (CAK) con 5 iteraciones

	Ne/W	k	α
50000 K	3.1d14	0.227	0.482
	3.1d11	0.207	0.498
	3.1d8.	0.208	0.492
40000 K	1.8d14	0.097	0.584
	1.8d11	0.089	0.595
	1.8d8.	0.09	0.589
30000 K	1.0d14	0.031	0.691
	1.0d11	0.03	0.693
	1.0d8.	0.031	0.688
20000 K	3.0d13	0.078	0.545
	3.0d10	0.112	0.521
	3.0d7.	0.084	0.537
15000 K	1.3d13	0.431	0.441
	1.3d10	0.452	0.439
	1.3d7.	0.488	0.43
10000 K	3.2d12	1395	-7.89
	3.2d9.	0.297	0.286
	3.2d6.	0.372	0.155
8000 K	1.7d12	6483	-5.27
	1.7d9.	1448	-5.64
	1.7d6.	4555	-6.2
6000 K	6.8d11	1152	-17.6
	6.8d8.	360	-20.5
	6.8d6.	302	-20.4

T_{eff} (K)	log g	δ	N_e/W (cm^{-3})	k	α
6000	0.5	0.16	6.8(+6)	0.018	0.502
			6.8(+8)	0.029	0.465
			6.8(+11)	0.272	0.444
8000	1.0	0.02	1.7(+6)	0.110	0.521
			1.7(+9)	0.105	0.542
			1.7(+12)	0.108	0.555
10,000	1.5	0.05	3.2(+6)	0.288	0.499
			3.2(+9)	0.362	0.538
			3.2(+12)	0.370	0.540
15,000	2.0	0.12	1.3(+7)	0.189	0.505
			1.3(+10)	0.253	0.511
			1.3(+13)	0.945	0.517
20,000	2.5	0.089	3.0(+7)	0.140	0.559
			3.0(+10)	0.477	0.506
			3.0(+13)	0.617	0.523
30,000	3.5	0.12	1.0(+8)	0.093	0.576
			1.0(+11)	0.156	0.609
			1.0(+14)	0.571	0.545
40,000	4.0	0.12	1.8(+8)	0.051	0.684
			1.8(+11)	0.174	0.606
			1.8(+14)	0.533	0.571
50,000	4.5	0.092	3.1(+8)	0.089	0.640
			3.1(+11)	0.178	0.606
			3.1(+14)	0.472	0.582

- Nueva base de datos de líneas
- Diferente método de obtención (autoconsistente)

¡Gracias!