CONSEQUENCES OF ROTATIONAL MIXING IN LATE TYPE MASSIVE STARS

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We have examined further the consequences of mixing induced by rotation in massive stars (Pop I composition: X = 0.7; Y = 0.27) in the mass range 40 - 100 $M_\odot$. The basic physics and a detailed examination for a 60 $M_\odot$ model has recently been published (Sreenivasan and Wilson 1985b), as has a detailed examination of supergiants without such mixing (Sreenivasan and Wilson 1985a). We shall therefore not go into the background of our computation here, but merely summarize our present findings.

The first result is that rotational mixing due to an extended core in the main sequence phase has the consequence that in all cases but one (M_O = 80 $M_\odot$, where M_O = Zero Age Main Sequence mass) the models exhaust their core helium on the red side of the HR diagram.

We present a table below to show the changes in Blue to Red Supergiant ratios. This is to be compared with our discussion of B/R ratios in our Supergiants paper (Sreenivasan and Wilson 1985a) and the Table 5 there. Also, the new M_{BOL} - log T_{eff} diagram of Humphreys and McElroy (1984) reveals a less steep slope for the envelope of observed stars, showing the absence of red supergiants above it.

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TABLE I

M_O(ZAMS)	40	60	80	100
M(X=0)	30.0	43.7	55.4	76.9
M(Y=0)	27.0	33.7	52.6	66
V_s(ZAMS)	140	265	210	98
f	0.157	0.281	0.214	0.099
$\dot{M}$(ZAMS)	1.2	3.0	4.3	6.3
$\dot{M}$(RGB)	8	30	-	50
τ_B/τ_R	38.1	0.41	∞	0.75
$X_s(Y_c=0)$	0.57	0.38	0.22	0.31
$q_{He}(Y_c=0)$	0.69	0.95	0.96	0.77

UNITS: $M(M_\odot)$; $V(km\ s^{-1})$; $\dot{M}(10^{-6}\ M_\odot\ yr^{-1})$

We have found from our model calculations that higher spins on the ZAMS result in greater mass-loss and a tendency for models to turn towards the blue as they age. There is also to be expected a distribution of spin speeds for a ZAMS model of given M_O. Thus a comparison of theoretical B/R ratios with those observed should incorporate the rotational history of models.

We therefore conclude that our spinning models predict higher effective temperatures for WR stars (Sreenivasan and Wilson 1982), a much broader main sequence due to mixing resulting from an extended core and the possibility of predicting the observed Blue/Red supergiant ratios when the rotational history of the stars is taken into account.

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The lower slope of the envelope of observed stars demonstrated recently by Humphreys and McElroy (1984) is consistent with the consequence of rotational mixing in massive stars.

Fuller details of this investigation will be published elsewhere.

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