

ASTROPHYSICS AND SPACE SCIENCE LIBRARY

---

EFFECTS  
OF MASS LOSS  
ON STELLAR EVOLUTION

Edited by C. Chiosi and R. Stalio

---

VOLUME 89

PROCEEDINGS



D. REIDEL PUBLISHING COMPANY

DORDRECHT, HOLLAND / BOSTON, U.S.A. / LONDON, ENGLAND

# EFFECTS OF MASS LOSS ON STELLAR EVOLUTION

# ASTROPHYSICS AND SPACE SCIENCE LIBRARY

A SERIES OF BOOKS ON THE RECENT DEVELOPMENTS  
OF SPACE SCIENCE AND OF GENERAL GEOPHYSICS AND ASTROPHYSICS  
PUBLISHED IN CONNECTION WITH THE JOURNAL  
SPACE SCIENCE REVIEWS

## *Editorial Board*

J. E. BLAMONT, *Laboratoire d'Aeronomie, Verrières, France*

R. L. F. BOYD, *University College, London, England*

L. GOLDBERG, *Kitt Peak National Observatory, Tucson, Ariz., U.S.A.*

C. DE JAGER, *University of Utrecht, The Netherlands*

Z. KOPAL, *University of Manchester, England*

G. H. LUDWIG, *NOAA, National Environmental Satellite Service, Suitland, Md., U.S.A.*

R. LÜST, *President Max-Planck-Gesellschaft zur Förderung der Wissenschaften, München, F.R.G.*

B. M. McCORMAC, *Lockheed Palo Alto Research Laboratory, Palo Alto, Calif., U.S.A.*

H. E. NEWELL, *Alexandria, Va., U.S.A.*

L. I. SEDOV, *Academy of Sciences of the U.S.S.R., Moscow, U.S.S.R.*

Z. ŠVESTKA, *University of Utrecht, The Netherlands*

VOLUME 89  
PROCEEDINGS

# EFFECTS OF MASS LOSS ON STELLAR EVOLUTION

IAU COLLOQUIUM NO. 59  
HELD IN MIRAMARE, TRIESTE, ITALY, SEPTEMBER 15–19, 1980

Edited by

C. CHIOSI

*Istituto di Astronomia, Padova, Italy*

and

R. STALIO

*Osservatorio Astronomico, Trieste, Italy*



D. REIDEL PUBLISHING COMPANY  
DORDRECHT : HOLLAND / BOSTON : U.S.A.  
LONDON : ENGLAND

Library of Congress Cataloging in Publication Data

Main entry under title:

**CIP**

Effects of mass loss on stellar evolution.

(Astrophysics and space science library; v. 89. Proceedings)

Includes indexes.

1. Stars—Evolution—Congresses. 2. Stars—Masses—Congresses.  
I. Chiosi, C. (Cesare) II. Stalio, R. (Roberto) III. International  
Astronomical Union. IV. Title: IAU colloquium no. 59. V. Series:  
Astrophysics and space science library; v. 89. VI. Series: Astrophysics  
and space science library; v. 89. Proceedings.

QB806.E33 523.7 81-7310

ISBN 90-277-1292-1

AACR2

---

Published by D. Reidel Publishing Company,  
P.O. Box 17, 3300 AA Dordrecht, Holland.

Sold and distributed in the U.S.A. and Canada  
by Kluwer Boston Inc.,  
190 Old Derby Street, Hingham, MA 02043, U.S.A.

In all other countries, sold and distributed  
by Kluwer Academic Publishers Group,  
P.O. Box 322, 3300 AH Dordrecht, Holland.

D. Reidel Publishing Company is a member of the Kluwer Group.

All Rights Reserved

Copyright © 1981 by D. Reidel Publishing Company, Dordrecht, Holland  
No part of the material protected by this copyright notice may be reproduced or  
utilized in any form or by any means, electronic or mechanical  
including photocopying, recording or by any informational storage and  
retrieval system, without written permission from the copyright owner

Printed in The Netherlands

TABLE OF CONTENTS

<i>Preface</i>	xv
<i>List of Participants</i>	xvii
<i>Introductory Address</i>	xxi
<u>SESSION I</u> - WINDS FROM EARLY TYPE STARS: OBSERVATIONS	
P.S. CONTI: Observations of stellar winds in early type stars (invited lecture)	1
H.J.G.L.M. LAMERS: The dependence of mass loss on the basic stellar parameters. (invited paper)	19
A.J. WILLIS: The velocity characteristics of WR stellar winds	27
K.A. van der HUUCHT and P.S. CONTI: The iron curtain of the WC 9 star HD 164270.	35
R.E. CERSHBERG: Is a stellar wind inherent in WR-stars throughout the whole of their evolution?	39
M. PERINOTTO and N. PANAGIA: Wind characteristics of the O7 n star HD 217086 in the Cep OB 3 association	41
M. PERINOTTO, P. BENVENUTI and C. CACCIARI: Mass loss from central stars of planetary nebulae	45
E.G. TANZI, M. TARENGHI and N. PANAGIA: Mass loss rates of OB stars derived from infra-red observations	51
Y. ANDRILLAT and Ch. FEHRENBACH: Profils de la raie $H_{\alpha}$ par television analogique	57
B. WOLF, O. STAHL and W.J. ALTENHOFF: Radio observations and the mass flow rate of $\alpha$ Cyg (A2 Ia)	61

M.J. BARLOW, L.J. SMITH and A.J. WILLIS: Mass loss rates for twenty one Wolf-Rayet stars	65
S. BENSAMMAR, S. GAUDENZI, C. ROSSI, H.M. JOHNSON, P.S. THÉ, E.J. ZUIDERWIJK and R. VIOTTI: Mass outflow in AG Carinae and a comparison with P Cygni	67
R. VIOTTI, L. ROSSI and F. D'ANTONA: Mass loss from hot stars below the main sequence	71
L. CARRASCO: On the stellar gravity and effective temperature dependence of the ratio of terminal to escape velocities in stellar winds	75
S.P. TARAFDAR: Observational evidences of stellar wind	79
R.H. MENDEZ and A.D. VERGA: The radial velocity variations in IC 418	83
<u>SESSION II</u> - WINDS FROM LATE TYPE STARS: OBSERVATIONS	
A.K. DUPREE: Mass loss from cool stars (invited lecture)	87
L. GOLDBERG: Outflow of matter in the chromosphere of $\alpha$ Orionis	111
T. TANABE and F. KAMIJO: Mass loss from $\alpha$ Ori	113
M. BOYARCHUK: On possible mass loss from the supergiant RHO Cassiopeia	117
S.T. RIDGWAY and E.D. FRIEL: Photospheric molecular line profiles in cool stars	119
<u>SESSION III</u> - WINDS FROM EARLY TYPE STARS: THEORY	
A.G. HEARN: The theory of winds in early type stars (invited lecture)	125
R. COSTERO, V. DOAZAN, R. STALIO and R.N. THOMAS: Stellar variability and individuality: observations and implications (invited paper)	131

T. MONTMERLE, M. CASSE and J. PAUL: Possible links between supersonic stellar winds and the origin of cosmic rays	155
P.B. KUNASZ and F. PRADERIE: Line formation in the wind of Alpha Cygni	159
W.R. HAMANN: Empirical wind models from detailed UV line fits: Tau Scorpii	161
M. LEROY and J.P.J. LAFON: Can hot star winds be driven by radiation pressure?	167
N. PANAGIA and F. MACCHETTO: Radiative wind acceleration in early type stars.	173
M. FELLI and N. PANAGIA: Radio observations of O-type stars	179
H.J.G.L.M. LAMERS: Narrow components in UV line profiles as evidence for a two component stellar wind for O and B stars	181
<u>SESSION IV - WINDS FROM LATE TYPE STARS: THEORY</u>	
J.L. LINSKY: Winds in late-type stars: Mechanisms of mass outflow. (invited lecture)	187
C.D. ANDRIESSE: The fluctuation theory of the stellar mass loss (invited paper)	213
<u>SESSION V - MASS LOSS AND STELLAR EVOLUTION: MASSIVE STARS</u>	
C. CHIOSI: Mass loss and evolution of massive stars (invited lecture)	229
G.F. BISIACCHI and C. FIRMANI: The fraction of O-type supergiants in our galaxy in the LMC and in the SMC: an evidence of the correlation between mass loss rate and chemical abundance	255
H.J. FALK and R. MITALAS: Evolution of a 30 $M_{\odot}$ star: the interplay of nuclear burning and mass loss	261

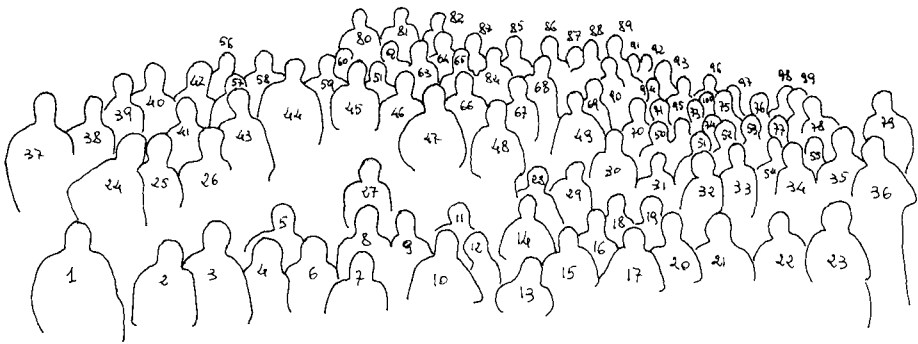
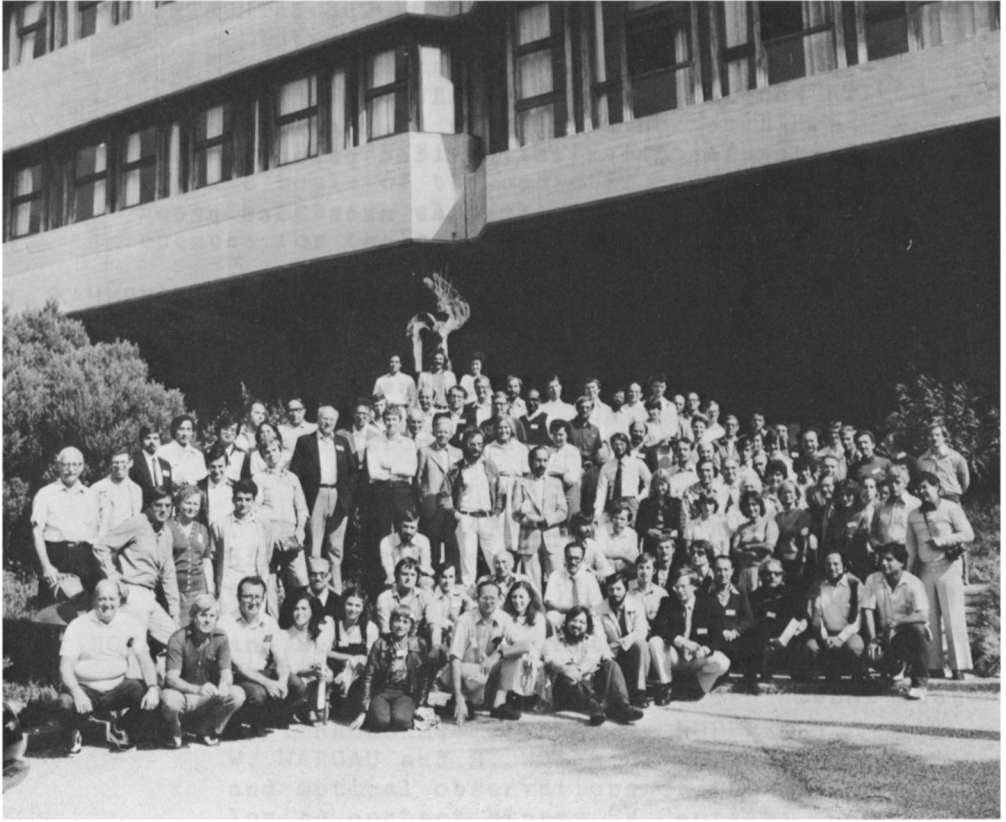


L.R. YUNGELSON, A.G. MASSEVITCH, A.V. TUTUKOV: On the significance of mass loss for the evolution of massive stars	265
G. MURATORIO, S. BENSAMMAR, A. CASSATELLA, M. FRIEDJUNG and R. VIOTTI: The ultra violet to infrared spectrum of the large mass loss LMC supergiant S22 = HD 34664	271
D. VANBEVEREN: The influence of mass loss by stellar wind on the evolution of massive helium burning stars	275
P. HELLINGS and D. VANBEVEREN: Stellar evolution with SMC chemical abundances	279
A. MAEDER: Massive stars burning helium: the numbers of WR stars and red supergiants in galaxies	283
Y. TANAKA, N. ARIMOTO and M. TAKEUTI: Thermal instability of hydrogen burning shells in very massive stars	289
C. CHIOSI and L. GREGGIO: Effects of a stochastic initial mass function on the upper main sequence band	293
C. CHIOSI, G. BERTELLI, E. NASI, L. GREGGIO: Mass loss from metal-poor stars	297
A.F.J. MOFFAT: Masses of Magellanic Wolf-Rayet stars: mass loss and evidence for a WR subclass vs. mass relation	301
V.S. NIEMELA: How massive the Wolf-Rayet stars are?	307
P.S. CONTI and P. MASSEY: The hydrogen/helium ratio on the surface of Wolf-Rayet stars	311
A. GOMEZ, M.C. LORTET and A. PITAULT: Peculiarities in the distribution of galactic Wolf-Rayet stars: constraints on evolutionary scenarios?	315
 <u>SESSION VI</u> - MASS LOSS AND STELLAR EVOLUTION: LOW MASS STARS	
A. RENZINI: Evolutionary effects of mass loss in low mass stars (invited lecture)	319

V. WEIDEMANN: The initial/final mass relation for stellar evolution with mass loss	339
A. HARPAZ and A. KOVETZ: Formation of a planetary nebula by continuous mass loss	345
S. KWOK: Effects of mass loss on the formation of planetary nebulae	347
L.A. WILLSON: Miras, mass loss, and the origin of planetary nebulae	353
V. CASTELLANI and A. TORNAMBE: Theoretical evidence of mass loss from globular cluster stars	357
R. EBERT and H. ZINNECKER: Effect of mass gain on stellar evolution.	361
 <u>SESSION VII</u> - MASS LOSS AND STELLAR EVOLUTION: INTERMEDIATE MASS STARS	
I. IBEN Jr.: On the consequences of mass loss from intermediate mass stars (invited lecture)	373
D.H. McNAMARA and K.A. FELTZ Jr.: A determination of the characteristics of Cepheids from B-type companions	389
C.G. DAVIS: What "masses" for Cepheids?	397
M.Y. FUJIMOTO, I. IBEN Jr. and S.A. BECKER: Response of low-mass main sequence stars to accretion	401
 <u>SESSION VIII</u> - EFFECTS OF MASS LOSS ON THE EVOLUTION OF BINARY STARS	
C. de LOORE: The influence of mass loss on the evolution of binaries (Invited lecture)	405
M. PLAVEC: Mass loss from interacting close binary systems (invited lecture, presented by C.D. Keyes)	431
G. HAMMERSCHLAG-HENSBERGE: Ionization effects in stellar winds of massive X-ray binaries	457

D. VANBEVEREN: Non conservative massive binary evolution (how much mass leaves the binary during the evolution from OB+OB to WR+OB)	461
C. DOOM and J.P. DE GREVE: On the evolutionary time scale of the accreting component in massive close binaries: consequences for the supernova event	465
N. KAMESWARA RAO: Observation of mass loss in R Cr B during the visual light minimum	469
F. MARDIROSSIAN and G. GIURICIN: Non conservative evolutionary scenario for 100 Algols	473
E.G. TANZI, L. MARASCHI, M. TARENGHI and A. TREVES: Infrared observations and mass loss of the binary system V861 Sco	477
I.D. HOWARTH and R. WILSON: The nature of V861 Sco (=HD 152667)	481
H. DRECHSEL, H.D. RADECKE, J. RAHE, G. RUPPRECHT, W. WARGAU and B. WOLF: Ultraviolet and optical observations of the mass-losing contact binary SV Centauri	487
G.A. BAKOS and J. TREMKO: Mass transfer and stellar wind effects in the eclipsing binary RT Andromedae	491
M. FRIEDJUNG: Properties of optically thick winds driven by radiation pressure	495
S. KWOK: Interacting stellar winds in a binary system	499
Th.J. van der LINDEN: Evolutionary computations for intermediate mass close binary systems	503
J. DOMMANGET: Is this diagram an argument for binary orbital evolution due to mass-loss?	507
P.L. SELVELLI and A. CASSATELLA: Nova AQL 1918: a nude old nova	515

<u>SESSION IX</u> - EFFECTS OF MASS LOSS ON THE INTERSTEL LAR MEDIUM	
M.A. DOPITA and I.R. WILSON: Stellar mass loss and HII region morphology in Magellanic ir regular galaxies (Invited paper)	523
A. SERRANO and M. PEIMBERT: Stellar mass loss and galactic chemical evolution	535
J. ZOREC: Subionization and decelerated flow in the vicinity of a B shell star	539
C. CHIOSI and F. MATTEUCCI: Mass loss and $\Delta Y/\Delta Z$ ra tio	543
N. DALLAPORTA: Concluding Remarks	551
<i>Author Index</i>	561
<i>Subject Index</i>	564



1. S. Canziani
2. I. Iben Jr.
3. C. Chiosi
4. F. Matteucci
5. W. Rumpl
6. L. Greggio
7. P. Pismis
8. D. Vanbeveren
9. H. Hensberge
10. J. Linsky
11. C. de Loore
12. G. Hammerschlag-Hensberge
13. A. Serrano
14. A. Maeder
15. R. Mendez
16. Th. van der Linden
17. K. van der Hucht
18. A. Willis
- 19.
20. F. Ciatti
21. G. Bisiacchi
22. R. Costero
23. G. Tektunali
24. L. Varin
25. V. Niemela
26. G. Muratorio
27. P. Hellings
- 28.
29. P. Wood
30. L. Willson
- 31.
32. S. Vauclair
33. A. Dupree
34. L. Bianchi
35. C. Andriese
36. L. Carrasco
37. M. Shapiro
38. M. Friedjung
39. L. Crivellari
40. Y. Tanaka
41. L. Secco
42. M. Fujimoto
43. W. Hamann
44. D. McNamara
45. S. Ridgway
46. V. Weidemann
47. H. Henrichs
48. H. Nussbaumer
49. R. Viotti
50. S. Becker
51. L. Goldberg
52. Y. Andrillat
53. M. Franco
54. A. Hearn
55. R. Faraggiana
56. E. Kontizas
57. M. Kontizas
- 58.
59. M. Alaverdian
60. C. Morossi
61. N. Dallaporta
62. G. Bertelli
63. R. Stalio
64. C. Davis
65. J. Dommanget
66. M. Hack
67. A. Boyarchuk
68. H. Falk
69. H. Kirbiyk
70. H. Lamers
71. P. Conti
72. C. Fehrenbach
73. N. Panagia
74. J. Morlborough
- 75.
76. T. Montemerle
77. Mr. Andrillat
78. J. Lafon
79. H. Zinnecker
80. A. Tornambé
81. A. Renzini
82. E. Nasi
83. C. Keyes
84. S. Tarafdar
85. Z. Sima
86. M. Dopita
87. K. Rao
88. R. Gershberg
89. W. Seggewiss
90. M. Lortet
91. J. Sahade
92. P. Kunasz
- 93.
94. L. Pigatto
95. G. Barbaro
96. A. Moffat
97. B. Wolf
98. J. De Grève
99. A. Kovetz
100. L. Malagnini