

Problems of Solar and Stellar Oscillations

*Proceedings of the 66th IAU Colloquium
held at the Crimean Astrophysical Observatory, U.S.S.R.,
1-5 September, 1981*

Edited by

D. O. GOUGH

Institute of Astronomy, Cambridge

Reprinted from

Solar Physics, Vol. 82, Nos. 1/2



D. Reidel Publishing Company
Dordrecht : Holland / Boston : U.S.A.

PROBLEMS OF SOLAR AND STELLAR OSCILLATIONS

Problems of Solar and Stellar Oscillations

*Proceedings of the 66th IAU Colloquium
held at the Crimean Astrophysical Observatory, U.S.S.R.,
1-5 September, 1981*

Edited by

D. O. GOUGH

Institute of Astronomy, Cambridge

Reprinted from

Solar Physics, Vol. 82, Nos. 1/2



D. Reidel Publishing Company
Dordrecht : Holland / Boston : U.S.A.

ISBN 90-277-1554-8

All Rights Reserved

Copyright © 1983 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 Belgium

TABLE OF CONTENTS

Problems of Solar and Stellar Oscillations

(*Proceedings of the 66th IAU Colloquium*)

D. O. GOUGH / Foreword	7
V. A. KOTOV, A. B. SEVERNÝ, T. T. TSAP, I. G. MOISEEV, V. A. EFANOV, and N. S. NESTEROV / Manifestation of the 160-min Solar Oscillations in Velocity and Brightness (Optical and Radio Observations) (<i>Invited Review</i>)	9
V. A. KOTOV, S. KOUTCHMY, and O. KOUTCHMY / Observation of Global 160-min Infrared (Differential) Intensity Variation of the Sun	21
PHILIP H. SCHERRER and JOHN M. WILCOX / Structure of the Solar Oscillation with Period near 160 Minutes	37
ROBIN STEBBINS and CHRISTOPHER WILSON / The Measurement of Long-Period Oscillations at Sacramento Peak Observatory and South Pole	43
GÉRARD GREC, ERIC FOSSAT, and MARTIN A. POMERANTZ / Full-Disk Observations of Solar Oscillations from the Geographic South Pole: Latest Results (<i>Invited Review</i>)	55
M. WOODARD and H. HUDSON / Solar Oscillations Observed in the Total Irradiance	67
P. H. SCHERRER, J. M. WILCOX, J. CHRISTENSEN-DALSGAARD, and D. O. GOUGH / Detection of Solar Five-Minute Oscillations of Low Degree	75
RANDALL J. BOS and HENRY A. HILL / Detection of Individual Normal Modes of Oscillation of the Sun in the Period Range from 2 hr to 10 min in Solar Diameter Studies	89
F. L. DEUBNER / Helioseismology with High Degree <i>p</i> -Modes (<i>Invited Review</i>)	103
EDWARD J. RHODES, JR., JOHN W. HARVEY, and THOMAS L. DUVAL, JR. / Recent Observations of High-Degree Solar <i>p</i> -Mode Oscillations at the Kitt Peak National Observatory (<i>Invited Review, Abstract</i>)	111
S. E. FORBUSH, M. A. POMERANTZ, S. P. DUGGAL, and C. H. TSAO / Statistical Considerations in the Analysis of Solar Oscillation Data by the Superposed Epoch Method	113
G. KOVÁCS / On the Accuracy of Frequency Determination by an Auto-regressive Spectral Estimator	123
HENRY A. HILL, RANDALL J. BOS, and THOMAS P. CAUDELL / On the Origin of Oscillations in a Solar Diameter Observed through the Earth's Atmosphere: A Terrestrial Atmospheric or a Solar Phenomenon	129
J. RÖSCH and R. YERLE / Solar Diameter(s)	139
F.-L. DEUBNER and J. LAUFER / Short-Period Oscillations	151
V. E. MERKULENKO, V. I. POLYAKOV, L. E. PALAMARCHUK, and N. V.	

LARIONOV / Spectral-Spatial Analysis of Wave Motions in the Region of the Temperature Minimum of the Sun's Atmosphere	157
R. T. STEBBINS, PHILIP R. GOODE, and HENRY A. HILL / Observation of Five-Minute-Period Gravity Waves in the Solar Photosphere (<i>Invited Review, Abstract</i>)	163
JØRGEN CHRISTENSEN-DALSGAARD and SØREN FRANDSEN / Radiative Transfer and Solar Oscillations (<i>Invited Review</i>)	165
G. R. ISAAK / A New Method for Determining the Helium Abundance in the Solar Atmosphere (<i>Invited Review</i>)	205
E. A. GAVRYUSEVA, YU. S. KOPYSOV, and G. T. ZATSEPIN / 160-min Oscillations of the Sun as a Means of Studying of Its Internal Structure	209
S. V. VORONTSOV and K. I. MARCHENKOV / Adiabatic Oscillations of Solar Models with a High-Z Convective Zone	215
P. A. KUZURMAN and A. A. PAMYATNYKH / Solar Models with Low Opacity	223
H. SHIBAHASHI and Y. OSAKI / Theoretical Eigenfrequencies of Solar Oscillations of Low Harmonic Degree l in Five-Minute Range (<i>Invited Review, Abstract</i>)	231
A. CLAVERIE, G. R. ISAAK, C. P. MCLEOD, H. B. VAN DER RAAY, and T. ROCA CORTES / Rotational Splitting of Solar Five-Minute Oscillations of Low Degree (<i>Invited Review, Abstract</i>)	233
G. R. ISAAK / Is There an Oblique Magnetic Rotator Inside the Sun? (<i>Invited Review, Abstract</i>)	235
N. I. KOBANOV / The Study of Velocity Oscillations in the Solar Photosphere Using the Velocity Subtraction Technique	237
EDWARD J. RHODES, JR., ROBERT F. HOWARD, ROGER K. ULRICH, and EDWARD J. SMITH / A New System for Observing Solar Oscillations at the Mount Wilson Observatory. I: System Design and Installation	245
W. DZIEMBOWSKI / Resonant Coupling between Solar Gravity Modes (<i>Invited Review</i>)	259
JEAN-PIERRE POYET / Derivation of the Amplitude Equations of Acoustic Modes of an Unstable Semi-Infinite Polytrope (<i>Invited Review</i>)	267
J. PERDANG / Kolmogorov Unstable Stellar Oscillations	297
A. G. KOSOVICHEV and A. B. SEVERNÝ / On the Excitation of Oscillations of the Sun (Numerical Models)	323
M. KNÖLKER and M. STIX / A Convenient Method to Obtain Stellar Eigenfrequencies	331
GAETANO BELVEDERE, DOUGLAS GOUGH, and LUCIO PATERNÒ / On the Influence of Nonlinearities on the Eigenfrequencies of Five-Minute Oscillations of the Sun	343
L. M. B. C. CAMPOS / On Waves in Non-Isothermal, Compressible, Ionized and Viscous Atmospheres	355
Y. D. ŽUGŽDA, V. LOCANS, and J. STAUDE / Seismology of Sunspot Atmospheres	369

S. V. VORONTSOV / Adiabatic Oscillations of a Differentially Rotating Star. Second-Order Perturbation Theory	379
S. I. BLINNIKOV and M. YU. KHLOPOV / Excitation of the Solar Oscillations by Objects Consisting of γ -Matter	383
JEAN LATOUR, JURI TOOMRE, and JEAN-PAUL ZAHN / Nonlinear Anelastic Modal Theory for Solar Convection (<i>Invited Review</i>)	387
D. O. GOUGH and J. TOOMRE / On the Detection of Subphotospheric Convective Velocities and Temperature Fluctuations	401
FRANK HILL, JURI TOOMRE, and LAURENCE J. NOVEMBER / Variability in the Power Spectrum of Solar Five-Minute Oscillations (<i>Invited Review</i>)	411
V. A. DOGIEL / Maunder Convection Mode on the Sun and Long Solar Activity Minima	427
ROBERT HOWARD / Torsional Oscillations of the Sun (<i>Invited Review, Abstract</i>)	437
I. K. CSADA / Evidence for the Phi-Dependent Rotation-Oscillation of the Sun (and for the Driving Mechanism of the Asymmetric Dynamo)	439
V. S. BASHKIRTSEV, N. I. KOBANOV, and G. P. MASHNICH / The Observations of 80-min Oscillations in the Quiescent Prominences	443
A. M. GALPER, V. G. KIRILLOV-UGRYUMOV, N. G. LEIKOV, and B. I. LUCHKOV / Atmospheric Internal Gravity Waves as a Source of Quasi- periodic Variations of the Cosmic Ray Secondary Component and their Likely Solar Origin (<i>Invited Review</i>)	447
B. M. VLADIMIRSKY, V. P. BOBOVA, N. M. BONDARENKO, and V. K. VERETENNIKOVA / 160-min Pulsations in the Magnetosphere of the Earth Possibly Caused by Oscillations of the Sun	451
ICKO IBEN, JR. / An Essay on Stellar Oscillations and Evolution	457
JØRGEN CHRISTENSEN-DALSGAARD and SØREN FRANDSEN / Stellar 5 min Oscillations	469
R. M. BONNET / Helioseismology in the Future (<i>Invited Review</i>)	487

TABLE OF CONTENTS

ARTICLES

BASHKIRTSEV, V. S., N. I. KOBANOV, and G. P. MASHNICH / The Observations of 80-min Oscillations in the Quiescent Prominences	443
BELVEDERE, G., D. O. GOUGH, and L. PATERNÒ / On the Influence of Non-linearities on the Eigenfrequencies of Five-Minute Oscillations of the Sun	343
BLINNIKOV, S. I and M. YU. KHLOPOV / Excitation of the Solar Oscillations by Objects Consisting of γ -Matter	383
BOBOVA, V. P., <i>see</i> Vladimirska, B. M. <i>et al.</i>	
BONDARENKO, N. M., <i>see</i> Vladimirska, B. M. <i>et al.</i>	
BONNET, R. M. / Helioseismology in the Future (<i>Invited Review</i>)	487
BOS, R. J. and H. A. HILL / Detection of Individual Normal Modes of Oscillation of the Sun in the Period Range from 2 hr to 10 min in Solar Diameter Studies	89
BOS, R. J., <i>see</i> Hill, H. A. <i>et al.</i>	
CAMPOS, L. M. B. C. / On Waves in Non-Isothermal, Compressible, Ionized and Viscous Atmospheres	355
CAUDELL, T. P., <i>see</i> Hill, H. A. <i>et al.</i>	
CHRISTENSEN-DALSGAARD, J. and S. FRANDSEN / Radiative Transfer and Solar Oscillations (<i>Invited Review</i>)	165
CHRISTENSEN-DALSGAARD, J. and S. FRANDSEN / Stellar 5 min Oscillations	469
CHRISTENSEN-DALSGAARD, J., <i>see</i> Scherrer, P. H. <i>et al.</i>	
CLAVERIE, A., G. R. ISAAC, C. P. McLEOD, H. B. VAN DER RAAY, and T. ROCA CORTES / Rotational Splitting of Solar Five-Minute Oscillations of Low Degree (<i>Invited Review, Abstract</i>)	233
CSADA, I. K. / Evidence for the Phi-Dependent Rotation-Oscillation of the Sun (and for the Driving Mechanism of the Asymmetric Dynamo)	439
DEUBNER, F. L. / Helioseismology with High Degree p -Modes (<i>Invited Review</i>)	103
DEUBNER, F. L. and J. LAUFER / Short-Period Oscillations	151
DOGIEL, V. A. / Maunder Convection Mode on the Sun and Long Solar Activity Minima	427
DUGGAL, S. P., <i>see</i> Forbush, S. E. <i>et al.</i>	
DUVALL, Jr., T. L., <i>see</i> Rhodes, Jr., E. J. <i>et al.</i>	
DZIEMBOWSKI, W. / Resonant Coupling between Solar Gravity Modes (<i>Invited Review</i>)	259
EFANOV, V. A., <i>see</i> Kotov, V. A. <i>et al.</i>	
FORBUSH, S. E., M. A. POMERANTZ, S. P. DUGGAL, and C. H. TSAO / Statistical Considerations in the Analysis of Solar Oscillation Data by the Superposed Epoch Method	113
FOSSAT, E., <i>see</i> Grec, G. <i>et al.</i>	
FRANDSEN, S., <i>see</i> Christensen-Dalsgaard, J.	

TABLE OF CONTENTS

GALPER, A. M., V. G. KIRILLOV-UGRYUMOV, N. G. LEIKOV, and B. I. LUCHKOV / Atmospheric Internal Gravity Waves as a Source of Quasi-periodic Variations of the Cosmic Ray Secondary Component and their Likely Solar Origin (<i>Invited Review</i>)	447
GAVRYUSEVA, E. A., YU. S. KOPYSOV, and G. T. ZATSEPIN / 160-min Oscillations of the Sun as a Means of Studying of Its Internal Structure	209
GOODE, P. R., <i>see</i> Stebbins, R. T. <i>et al.</i>	
GOUGH, D. O. / Foreword	7
GOUGH, D. O. and J. TOOMRE / On the Detection of Subphotospheric Convective Velocities and Temperature Fluctuations	401
GOUGH, D. O., <i>see</i> Belvedere, G. <i>et al.</i>	
GOUGH, D. O., <i>see</i> Scherrer, P. H. <i>et al.</i>	
GREC, G., E. FOSSAT, and M. A. POMERANTZ / Full-Disk Observations of Solar Oscillations from the Geographic South Pole: Latest Results (<i>Invited Review</i>)	55
HARVEY, J. W., <i>see</i> Rhodes, Jr., E. J. <i>et al.</i>	
HILL, F., J. TOOMRE, and L. J. NOVEMBER / Variability in the Power Spectrum of Solar Five-Minute Oscillations (<i>Invited Review</i>)	411
HILL, H. A., R. J. BOS, and T. P. CAUDELL / On the Origin of Oscillations in a Solar Diameter Observed through the Earth's Atmosphere: A Terrestrial Atmospheric or a Solar Phenomenon	129
HILL, H. A., <i>see</i> Bos, R. J.	
HILL, H. A., <i>see</i> Stebbins, R. T. <i>et al.</i>	
HOWARD, R. / Torsional Oscillations of the Sun (<i>Invited Review, Abstract</i>)	437
HOWARD, R. F., <i>see</i> Rhodes, Jr., E. J. <i>et al.</i>	
HUDSON, H., <i>see</i> Woodard, M.	
IBEN, Jr., I. / An Essay on Stellar Oscillations and Evolution	457
ISAAK, G. R. / A New Method for Determining the Helium Abundance in the Solar Atmosphere (<i>Invited Review</i>)	205
ISAAK, G. R. / Is There an Oblique Magnetic Rotator Inside the Sun? (<i>Invited Review, Abstract</i>)	235
ISAAK, G. R., <i>see</i> Claverie, A. <i>et al.</i>	
KHLOPOV, M. YU., <i>see</i> Blinnikov, S. I.	
KIRILLOV-UGRYUMOV, V. G., <i>see</i> Galper, A. M. <i>et al.</i>	
KNÖLKER, M. and M. STIX / A Convenient Method to Obtain Stellar Eigen-frequencies	331
KOBANOV, N. I. / The Study of Velocity Oscillations in the Solar Photosphere Using the Velocity Subtraction Technique	237
KOBANOV, N. I., <i>see</i> Bashkirtsev, V. S. <i>et al.</i>	
KOPYSOV, YU. S., <i>see</i> Gavryuseva, E. A. <i>et al.</i>	
KOSOVICHEV, A. G. and A. B. SEVERNÝ / On the Excitation of Oscillations of the Sun (Numerical Models)	323
KOTOV, V. A., S. KOUTCHMY, and O. KOUTCHMY / Observation of Global 160-min Infrared (Differential) Intensity Variation of the Sun	21

TABLE OF CONTENTS

KOTOV, V. A., A. B. SEVERNÝ, T. T. TSAP, L. G. MOISEEV, V. A. EFANOV, and N. S. NESTEROV / Manifestation of the 160-min Solar Oscillations in Velocity and Brightness (Optical and Radio Observations) (<i>Invited Review</i>)	9
KOUTCHMY, O., <i>see</i> Kotov, V. A. <i>et al.</i>	
KOUTCHMY, S., <i>see</i> Kotov, V. A. <i>et al.</i>	
KOVÁCS, G. / On the Accuracy of Frequency Determination by an Autoregressive Spectral Estimator	123
KUZURMAN, P. A. and A. A. PAMYATNYKH / Solar Models with Low Opacity	223
LARIONOV, N. V., <i>see</i> Merkulenko, V. E. <i>et al.</i>	
LATOÛR, J., J. TOOMRE, and J.-P. ZAHN / Nonlinear Anelastic Modal Theory for Solar Convection (<i>Invited Review</i>)	387
LAUFER, J., <i>see</i> Deubner, F.-L.	
LEIKOV, N. G., <i>see</i> Galper, A. M. <i>et al.</i>	
LOCANS, V., <i>see</i> Žugžda, Y. D. <i>et al.</i>	
LUCHKOV, B. I., <i>see</i> Galper, A. M. <i>et al.</i>	
MARCHENKOV, K. I., <i>see</i> Vorontsov, S. V.	
MASHNICH, G. P., <i>see</i> Bashkirtsev, V. S. <i>et al.</i>	
MCLEOD, C. P., <i>see</i> Claverie, A. <i>et al.</i>	
MERKULENKO, V. E., V. I. POLYAKOV, L. E. PALAMARCHUK, and N. V. LARIONOV / Spectral-Spatial Analysis of Wave Motions in the Region of the Temperature Minimum of the Sun's Atmosphere	157
MOISEEV, L. G., <i>see</i> Kotov, V. A. <i>et al.</i>	
NESTEROV, N. S., <i>see</i> Kotov, V. A. <i>et al.</i>	
NOVEMBER, L. J., <i>see</i> Hill, F. <i>et al.</i>	
OSAKI, Y., <i>see</i> Shibahashi, H.	
PALAMARCHUK, L. E., <i>see</i> Merkulenko, V. E. <i>et al.</i>	
PAMYATNYKH, A. A., <i>see</i> Kuzurman, P. A.	
PATERNÒ, L., <i>see</i> Belvedere, G. <i>et al.</i>	
PERDANG, J. / Kolmogorov Unstable Stellar Oscillations	297
POLYAKOV, V. I., <i>see</i> Merkulenko, V. E. <i>et al.</i>	
POMERANTZ, M. A., <i>see</i> Forbush, S. E. <i>et al.</i>	
POMERANTZ, M. A., <i>see</i> Grec, G. <i>et al.</i>	
POYET, J.-P. / Derivation of the Amplitude Equations of Acoustic Modes of an Unstable Semi-Infinite Polytrope (<i>Invited Review</i>)	267
RHODES, Jr., E. J., J. W. HARVEY, and T. L. DUVALL, Jr. / Recent Observations of High-Degree Solar <i>p</i> -Mode Oscillations at the Kitt Peak National Observatory (<i>Invited Review, Abstract</i>)	111
RHODES, Jr., E. J., R. F. HOWARD, R. K. ULRICH, and E. J. SMITH / A New System for Observing Solar Oscillations at the Mount Wilson Observatory. I: System Design and Installation	245
ROCA CORTES, T., <i>see</i> Claverie, A. <i>et al.</i>	
RÖSCH, J. and R. YERLE / Solar Diameter(s)	139
SCHERRER, P. H. and J. M. WILCOX / Structure of the Solar Oscillation with Period near 160 Minutes	37
SCHERRER, P. H., J. M. WILCOX, J. CHRISTENSEN-DALSGAARD, and D. O. GOUGH / Detection of Solar Five-Minute Oscillations of Low Degree	75

TABLE OF CONTENTS

SEVERNÝ, A. B., <i>see</i> Kosovichev, A. G.	
SEVERNÝ, A. B., <i>see</i> Kotov, V. A. <i>et al.</i>	
SHIBAHASHI, H. and Y. OSAKI / Theoretical Eigenfrequencies of Solar Oscillations of Low Harmonic Degree l in Five-Minute Range (<i>Invited Review, Abstract</i>)	231
SMITH, E. J., <i>see</i> Rhodes, Jr., E. J. <i>et al.</i>	
STAUDE, J., <i>see</i> Žugžda, Y. D. <i>et al.</i>	
STEBBINS, R. and C. WILSON / The Measurement of Long-Period Oscillations at Sacramento Peak Observatory and South Pole	43
STEBBINS, R. T., P. R. GOODE, and H. A. HILL / Observation of Five-Minute-Period Gravity Waves in the Solar Photosphere (<i>Invited Review, Abstract</i>)	163
STIX, M., <i>see</i> Knölker, M.	
TOOMRE, J., <i>see</i> Gough, D. O.	
TOOMRE, J., <i>see</i> Hill, F. <i>et al.</i>	
TOOMRE, J., <i>see</i> Latour, J. <i>et al.</i>	
TSAO, C. H., <i>see</i> Forbush, S. E. <i>et al.</i>	
TSAP, T. T., <i>see</i> Kotov, V. A. <i>et al.</i>	
ULRICH, R. K., <i>see</i> Rhodes, Jr., E. J. <i>et al.</i>	
VAN DER RAAY, H. B., <i>see</i> Claverie, A. <i>et al.</i>	
VERETENNIKOVA, V. K., <i>see</i> Vladimírský, B. M. <i>et al.</i>	
VLADIMÍRSKÝ, B. M., V. P. BOBOVÁ, N. M. BONDARENKO, and V. K. VERETENNIKOVA / 160-min Pulsations in the Magnetosphere of the Earth Possibly Caused by Oscillations of the Sun	451
VORONTSOV, S. V. / Adiabatic Oscillations of a Differentially Rotating Star. Second-Order Perturbation Theory	379
VORONTSOV, S. V. and K. I. MARCHENKOV / Adiabatic Oscillations of Solar Models with a High-Z Convective Zone	215
WILCOX, J. M., <i>see</i> Scherrer, P. H.	
WILCOX, J. M., <i>see</i> Scherrer, P. H. <i>et al.</i>	
WILSON, C., <i>see</i> Stebbins, R.	
WOODARD, M. and H. HUDSON / Solar Oscillations Observed in the Total Irradiance	67
YERLE, R., <i>see</i> Rösch, J.	
ZAHN, J.-P., <i>see</i> Latour, J. <i>et al.</i>	
ZATSEPIN, G. T., <i>see</i> Gavryuseva, E. A. <i>et al.</i>	
ŽUGŽDA, Y. D., V. LOCANS, and J. STAUDE / Seismology of Sunspot Atmospheres	369