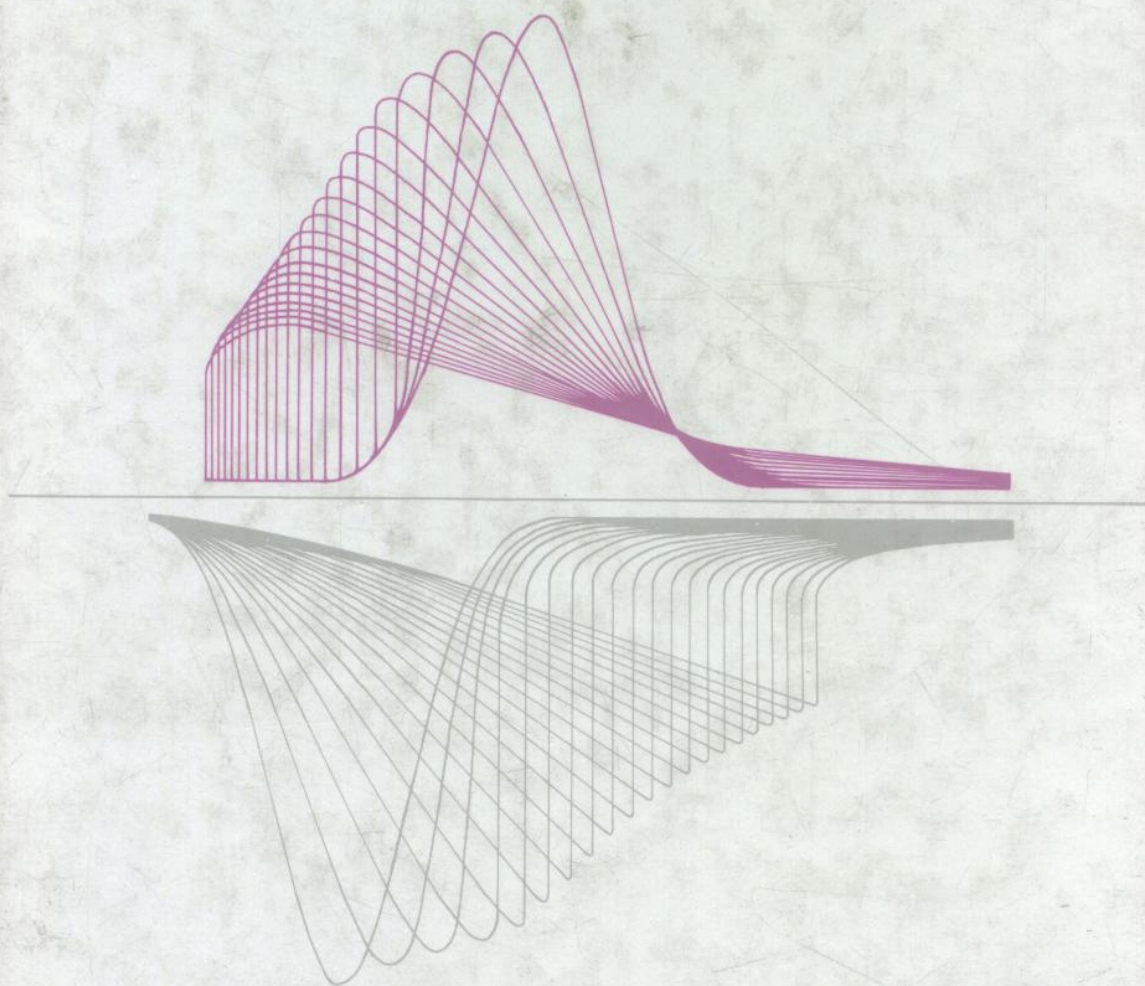


# FRONTIERS OF NONLINEAR ACOUSTICS 12th ISNA

Edited by M.F. HAMILTON and D.T. BLACKSTOCK



ELSEVIER APPLIED SCIENCE

# **FRONTIERS OF NONLINEAR ACOUSTICS**

## **12th ISNA**

*Edited by*

**M.F. HAMILTON**

**and**

**D.T. BLACKSTOCK**

*Department of Mechanical Engineering and Applied Research Laboratories,  
The University of Texas at Austin,  
Austin, Texas, USA*

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**FRONTIERS OF NONLINEAR ACOUSTICS**  
**12th ISNA**

This volume consists of papers presented at the 12th International Symposium on Nonlinear Acoustics (12th ISNA), Austin, Texas, USA, 27–31 August 1990.

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## Preface

This volume contains the Proceedings of the 12th International Symposium on Nonlinear Acoustics (ISNA), which was held during 27–31 August 1990 in Austin, Texas, USA. A total of 92 papers are contained in this volume, 7 of which were invited. The authors of the papers represent 12 different countries: China, Denmark, France, Germany, Italy, Japan, Norway, Spain, Sweden, the UK, the USA and the USSR.

The 1st ISNA, held in 1968, was largely in response to the then blossoming interest in finite amplitude sound that accompanied the discovery of the parametric array in the early 1960s. As demonstrated by the papers in these Proceedings, the parametric array remains an active area of research as we enter the 1990s. Also included in this volume are papers on waves containing shocks, propagation of finite amplitude sound through inhomogeneous media and in waveguides, nonlinear effects in sound beams, the parameter of nonlinearity, interaction of sound with bubbles, nonlinear waves in solids, cavitation, solitons and chaos. A substantial number of papers are related to biomedical applications of nonlinear acoustics. Most of them may be found in either the section on biomedical applications or the section on the parameter of nonlinearity.

The 12th ISNA, like previous Symposia in this series, provided an international forum for the discussion and documentation of new directions of research in nonlinear acoustics. Because the Symposia serve as benchmarks in the evolution of the field, it seems appropriate to consolidate information about previous Symposia which may not be readily accessible to even the most dedicated researchers in nonlinear acoustics. The dates, locations, nominal chairmen and relevant documentation for the previous 11 Symposia are as follows:

### *1st ISNA*

27 May 1968

New London, Connecticut, USA

R.H. Mellen, Chairman

*Application of Finite-Amplitude Acoustics to Underwater Sound*, Proceedings of a Seminar at Navy Underwater Sound Laboratory on 27 May 1968, edited by R.H. Mellen (Navy Underwater Sound Laboratory, New London, Connecticut, 1970) (AD 707 721, NUSL Report No. 1084, USAG Report No. 69-6).

**2nd ISNA**

10–11 November 1969

Austin, Texas, USA

T.G. Muir, Chairman

*Nonlinear Acoustics*, Proceedings of the 1969 Applied Research Laboratories Symposium, edited by T.G. Muir (Applied Research Laboratories, University of Texas at Austin, Austin, Texas, 1970) (AD 719 936).

**3rd ISNA**

1–2 April 1971

Birmingham, UK

H.O. Berktaý, Chairman

*Proceedings of Symposium on Nonlinear Acoustics Held at the University of Birmingham on 1st and 2nd April 1971* (British Acoustical Society, London, 1972).

**4th ISNA**

18–19 April 1972

Buffalo, New York, USA\*

D.T. Blackstock, Chairman

Program of the 83rd Meeting of the Acoustical Society of America, *Journal of the Acoustical Society of America*, Vol. 52, pp. 114–116 (Session B), pp. 121–123 (Session F), pp. 144–145 (Session R) (1972).

\*Held in conjunction with the 83rd Meeting of the Acoustical Society of America.

**5th ISNA**

20–22 August 1973

Copenhagen, Denmark

L. Bjørnø, Chairman

*Finite-Amplitude Wave Effects in Fluids*, Proceedings of the 1973 Symposium, edited by L. Bjørnø (IPC Science and Technology Press Ltd, Guildford, Surrey, UK, 1974).

**6th ISNA**

8–10 July 1975

Moscow, USSR

R.V. Khokhlov, Chairman

*Proceedings of the 6th International Symposium on Nonlinear Acoustics*, Vols. 1 and 2, edited by R.V. Khokhlov (Moscow State University Press, Moscow, 1976).

**7th ISNA**

19–21 August 1976

Blacksburg, Virginia, USA

A.H. Nayfeh, Chairman

*Abstracts of the 7th International Symposium on Nonlinear Acoustics*, edited by A.H. Nayfeh and J.E. Kaiser (Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 1976).

**8th ISNA**

3–6 July 1978

Paris, France

A. Zarembowitch, Chairman

8th International Symposium on Nonlinear Acoustics, *Journal de Physique*, Colloque C8, Supplément au No. 11, Tome 40 (1979).

**9th ISNA**

20–24 July 1981

Leeds, UK

D.G. Crighton, Chairman

*Ninth International Symposium on Nonlinear Acoustics, Book of Abstracts* (University of Leeds, UK, 1981).

**10th ISNA**

24–28 July 1984

Kobe, Japan

A. Nakamura, Chairman

*Proceedings of the 10th International Symposium on Nonlinear Acoustics*, edited by A. Nakamura (Teikohsha Press, Kadoma, Japan, 1984).

**11th ISNA**

24–28 August 1987

Novosibirsk, USSR

V.K. Kedrinskii, Chairman

*Problems of Nonlinear Acoustics*, Proceedings of IUPAP–IUTAM Symposium on Nonlinear Acoustics, Parts I and II, edited by V.K. Kedrinskii (Novosibirsk, USSR, 1987).

It should be noted that the custom of numbering the Symposia did not begin until the Copenhagen Symposium.

Financial support for the 12th ISNA was provided by Applied Research Laboratories of the University of Texas at Austin (ARL:UT), the US Office

of Naval Research (ONR), the International Union of Pure and Applied Physics (IUPAP) and the International Union of Theoretical and Applied Mechanics (IUTAM).

**M.F. HAMILTON**  
**D.T. BLACKSTOCK**  
*Cochairmen, 12th ISNA*

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