

# EUROMECH

# Final Report

EUROPEAN MECHANICS SOCIETY

Please send this report to the Secretary-General of EUROMECH, within one month after the Colloquium.

EUROMECH Colloquium No: **376**

Title: **Waves in Two-Phase Flows**

Dates and location: **27-30 April 1998, Istanbul, Turkey**

Chairman: **Can F. Delale (Istanbul)**

Co-Chairman: **David G. Crighton (Cambridge)**

Is there need of another Colloquium on the same or a related subject? Which year?

**Yes, but not earlier than the year 2002**

Full registration fee: **27 X 200 = 5,400 US dollars**

What other funding was obtained? **9,000 US dollars from TÜBİTAK, the Scientific & Technical Research Council of Turkey**

What were the participants offered? **and some other assistance from sponsors. Russian and Eastern European Scientists who presented papers were given free accommodation at İTÜ Mağka Sosyal Tesisleri. All participants were granted a welcoming party on 27.04.'98, a dinner on 28.04.'98 and half-day city tour including visits to Hagia Sophia, Topkapı Palace, etc.**

\* Number of members of EUROMECH (reduced registration fee): **16**  
200 US dollars

\* Number of non-members of EUROMECH (full registration fee): **11**  
235 US dollars

Number of participants from each country:

Austria	<u>1</u>	Germany	<u>3</u>	Romania	<u>2</u>
Belgium	<u>   </u>	Great Britain	<u>3</u>	Russia	<u>14</u>
Byelorussia	<u>   </u>	Greece	<u>   </u>	Slovakia	<u>   </u>
Bosnia	<u>   </u>	Hungary	<u>   </u>	Slovenia	<u>   </u>
Bulgaria	<u>   </u>	Ireland	<u>   </u>	Spain	<u>   </u>
Croatia	<u>   </u>	Italy	<u>   </u>	Sweden	<u>   </u>
Czech Republic	<u>2</u>	Latvia	<u>   </u>	Switzerland	<u>   </u>
Denmark	<u>1</u>	Lithuania	<u>   </u>	Ukraine	<u>1</u>
Estonia	<u>   </u>	Netherlands	<u>3</u>	Yugoslavia	<u>   </u>
Finland	<u>   </u>	Norway	<u>   </u>	Others	<u>25</u>
France	<u>5</u>	Poland	<u>4</u>	Total	<u>64</u>
Georgia	<u>   </u>	Portugal	<u>   </u>		

\* Those whose registration fees were waived are not included.

Please turn

C.F. Delale  
*[Signature]*

FINAL REPORT ON  
EUROMECH COLLOQUIUM 376  
WAVES IN TWO-PHASE FLOWS  
27-30 April 1998, Istanbul, Turkey

The Euromech Colloquium 376 Waves in Two-Phase Flows was held in Istanbul, Turkey at İ.T.Ü Vakfı Maçka Sosyal Tesisleri during the dates 27-30 April 1998. Topics discussed included waves in dispersed flow with nonequilibrium condensation and evaporation, waves in bubbly liquids, waves in porous media, waves in dusty gases, waves in fluidized beds together with capillarity, gravity, roll and water waves. There were sixty four participants from seventeen different countries (including Japan and the Americas) and fifty one papers were presented (all were oral). These papers were presented in fifteen sessions:

The first two sessions were devoted to fundamentals of two-phase flow. Academician R.I.Nigmatulin of the Ufa Branch of the Russian Academy of Sciences gave a plenary lecture on wave characteristics in two-phase fluids summarizing the specific features [1]. The papers presented by H.Gouin & S. Gavriluk of Universite d'Aix Marseille III were devoted to the derivation of the governing equations of two-fluid models with dissipation by a variational principle [2]. There was a paper presented by A. Kluwick of TU Wien which, by employing asymptotics, was aimed to derive evolution equations for weakly nonlinear waves at the free surface and at the interface of a flow consisting two layers of fluids with different, but constant densities. The paper by M.F. Göz of Martin-Luther University, Halle-Wittenberg was devoted to pattern formation in dispersed multiphase flows using averaged equations of motion for interacting and interpenetrating fluids [3]. A paper presented by V.Yu.Liapidevskii of Lavrentyev Institute of Hydrodynamics, Novosibirsk showed the occurrence of anomalous flow regimes and the nonuniqueness of the flow through a channel contraction for a wide class of multiphase flows [4].

There were three sessions on waves in bubbly liquids. K. Takayama from the Shock Wave Research Center, Sendai presented experimental results on the interaction of shock waves with gas bubbles in very viscous silicon oils as a model of explosive eruption of volcanoes. The results show that viscosity effects not only tend to attenuate the shock wave, but also to retard the bubble motion. The paper presented by Matsumoto from the University of Tokyo described numerical simulations and experimental data of one-dimensional transient shock

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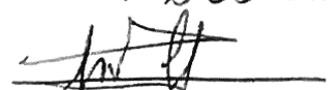
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wave phenomena in a liquid containing small gas bubbles [5]. V.K. Kedrinski from Lavrentyev Institute of Hydrodynamics, Novosibirsk presented results of numerical simulations of initiation mechanisms of detonation in liquified He and of large scale explosions of fuel containers in transportation as a result of shock and rarefaction wave interactions in active bubbly media. A.P. Szumowsky from Warsaw University of Technology presented results on the behavior of microscopic bubbles that occur in natural water by a series of expansion and compression waves. Large visible bubbles were observed during expansion when the pressure suddenly decreased. Teshukov from the Lavrentyev Institute of Hydrodynamics, Novosibirsk discussed kinetic equations describing the propagation of void waves in one-dimensional flows. D. Kardas from the Institute of Fluid Flow Machinery of the Polish Academy of Sciences, Gdansk discussed the non-recurrence in two-pressure model of bubbly flow from internal cause. S. Georgescu from the Polytechnic University of Bucharest reported simulation results on bubble cavity collapse and liquid jet formation in bursting gas bubble process. The contributions on waves in bubbly liquids by I.Sh. Akhatov of the Ufa Branch of the Russian Academy of Sciences and by A.A. Gubaidullin from the Tyumen Institute of Mechanics of Multiphase Systems, respectively, addressed the problem of forced oscillations of a gas bubble in a spherical liquid-filled flask [6] and the phenomenon of amplification of shock waves in bubbly liquids. The paper presented by K.A. Moerch of the Technical University of Denmark, Lyngby exhibited a new model of void formation at liquid-solid interfaces for a coherent explanation of the major experimental results of research in tensile strength of water and cavitation inception. J.D. Sherwood of Schlumberger Cambridge Research discussed oscillations of gas bubbles and slugs excited by flow through constriction.

A session on waves in porous media and dusty gases included the contributions of M.J. Buckingham from the the Scripps Institute of Oceanography of University of California, San Diego on the theory of compressional, transverse and interface waves in porous media, of D.M.J. Smeulders of Delft University of Technology on compressional and shear waves in layered poroelastic media [7], of E.S. Asmolov from Moscow TsAGI on the transmission of an acoustic wave through a screen of dusty gas and of A.N. Osipov from Lomonosov Moscow State University on wall effects behind a shock wave in a dusty gas.

In the session on waves in fluidized beds S.E. Harris of the University of Oxford discussed periodic wave evolution in gas-fluidized beds [8,9]. It was shown that weakly nonlinear periodic disturbances became fully nonlinear waves which approached a limiting amplitude and hence equilibrated. T. Ooshida of Tottori University discussed generic features of waves in two-phase flows as an interplay of drag, gravity and inertia [10]. A paper presented by C.R. Kaykayoglu of Istanbul University dealt with simulation of externally excited two-phase jet flow for industrial applications.

The session on gravity, roll and water waves contained papers which discussed the recent advances made in these fields. G. Iooss of INLN, Valbonne

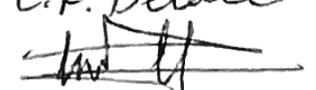
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discussed the following problems of two superposed layers of perfect fluids, the upper being of finite depth and the bottom of infinite depth [11,12] (i) gravity waves with two parameters, (ii) capillary-gravity waves with three parameters with surface tension acting on the upper free surface and (iii) capillary-gravity waves with interfacial tension as well (four parameters). F. Dias from INLN, Valbonne discussed the transition from two-dimensional to three dimensional water waves. It was shown that, if one considers capillary-gravity waves, one can find parameter regimes where dimension breaking bifurcations can be obtained within the framework of the so-called Benney-Roskes (or Davey-Stewartson) equations. The paper presented by A. Boudlal from Laboratoire de Mecanique de Lille addressed roll waves in slightly inclined conduits of arbitrary shape containing two-layered fluids [13]. A paper on roll waves in two-layered fluids was also presented by V.Y. Liapidevskii from Lavrentyev Institute of Hydrodynamics, Novosibirsk.

The session on waves in multiphase mixtures contained contributions presented by N.A. Pribaturin and V.E. Dontsov from the Institute of Thermophysics, Novosibirsk on pressure waves in multiphase media and by Z. Bilicki from the Institute of Fluid Flow Machinery, Gdansk on the investigation of stationary shock wave in the flow of water-vapor mixture [14].

There were three sessions devoted to condensation waves. M.E.H. van Dongen and G.Lamanna from Eindhoven University of Technology presented, respectively, experimental results conducted in wave-tubes on nucleation and condensation of natural gas [15,16] and on unsteady condensation in two-dimensional nozzles. F. Peters of the University of Essen presented experimental results of vapor condensation on a thin wire in an expansion tube [17]. M.Heiler from the University of Karlsruhe presented results on unsteady two-phase flows in cascades whereas M. Stastny from Skoda Turbiny, Pilsen considered homogeneous and heterogeneous condensation in steam turbine cascades. A.V. Chirikhin of TsAGI, Moscow presented numerical results of condensation waves in the nozzle of transonic aerodynamic tunnel. F. Marsik from the Institute of Thermomechanics of Academy of Sciences of Czech Republic, Prague presented results on the application and experimental verification of the Chapman-Jouguet condition for condensation waves. C.F. Delale from Istanbul University presented the asymptotic solution of subcritical Prandtl-Meyer flows with condensation and thermal choking in two-dimensions [18]. Y. Onishi from Tottori University discussed transient flows between cylindrical condensed phases. A. Eden from Bogazici University, Istanbul presented a model for compressible flow with phase transition using Van der Waals theory. B. Khuzhayarov of Samarkand Division of the Academy of Sciences of Uzbekistan discussed dynamics of perturbation at filtration of oil-gas-condensate mixtures.

The session on evaporation waves and boiling contained contributions presented by A. Reshetnikov and by V.K. Skokov, both from the Institute of Thermal Physics, Ekaterinburg, respectively, on jets of boiling-up liquid [19] and on waves and  $1/f$ -noise in boiling nitrogen [20]. In this session D.L. Frost of McGill

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University, Montreal presented experimental results on the dynamics of rapid vaporization due to partial venting of a liquified gas and J.R. Simoes-Moriera from Sao Paulo University discussed simple modeling of evaporation waves.

There were also contributions presented in a separate session by D.V. Lyubimov from Perm State University on parametric resonance at the interphase of phase separating media, by C.I. Gheorghiu from the Institute of Mathematics, Cluj on the stability of thin liquid layers flowing down a plane and by H. Demiray from Istanbul Technical University on amplitude modulation of nonlinear waves in a fluid-filled elastic tube.

The discussion in the closing session was chaired by A. Kluwick of TU Wien indicating the balance between theoretical and experimental contributions in the Colloquium. The need for further interactions between various groups working on waves in multiphase flows were emphasized by different participants.

As for the social program a half-day city tour on April 29 comprising visits to historical places such as Hagia Sophia, Blue Mosque and Topkapi Palace was organized. The Colloquium Banquet took place on the same night at Orient House with highlights of Turkish show.

The Colloquium closed up with the will of all participants to meet in a few years time at an IUTAM meeting on the same topic in Europe or the Americas.

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Co-chairmen of EUROMECH 376