MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

Tagungsbericht 3/1987

Mathematische Theorien der Fluide

19.1. bis 23.1.1987

Die Tagung wurde von den Professoren Wolfgang Bürger (Karlsruhe) und Ingo Müller (Berlin) abgehalten. 37 Teilnehmer trugen durch ihre Vorträge und Diskussionsbeiträge zum Gelingen dieser Tagung bei. Die 37 Vorträge ordneten sich in 7 Sektionen:

a) Rheologie
b) Wellen
c) Viskoelastizität, Plastizität
d) Elastizität
e) Martensitische Transformationen
f) Thermodynamik
g) Thermodynamik und kinetische Gastheorie

Im Mittelpunkt des Interesses stand die mathematische Formulierung von Zustandsgleichungen unterschiedlichster Materialien wie Plasmen, polarer Flüssigkeiten, Mehrphasenmischungen, Polymernetzwerke, realer Gase, klassischer und relativistischer entarteter Gase sowie viskoelastischer und plastischer Körper. In mehreren Beiträgen wurden Zustandsgleichungen an konkreten Randwertproblemen überprüft. Dabei wurden besonders Wellenphänomene, die Stabilität von Strömungen und Eindeutigkeitsprobleme behandelt. Schwerpunkt einer anderen Gruppe von Vorträgen war die mikroskopische Begründung makroskopischer Gleichungen für Flüssigkeiten und Gase mit der Vorgabe, daß diese Gleichungen ein System quasilinearer hyperbolischer Gleichungen darstellen sollten. Diese sind Gegenstand der erweiterten Thermodynamik. Weitere Vorträge widmeten sich neueren Entwicklungen der Theorie der Plastiziät und der Phasenübergänge in Memory-Legierungen.

Besonderen Anklang fand ein Abendvortrag von Professor W. Bürger über die Mechanik und Thermodynamik von Spielzeugen mit vielen interessanten Experimenten.

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Vortragsauszüge

After-dinner Talk:

W. BUERGER

Scientific toys

Scientific toys can be a serious challenge to the applied mathematician. The mechanisms of very common toys seem to have not been properly understood. In the lecture I demonstrated a fairly large number of mechanical and thermal toys (as well as some freehand experiments) and explained mathematical models for their operation. It is not obvious that the raw egg wins the race against its hard-boiled opponent when both are rolling on an inclined plane. Does the "slinky" win the race against the chain when we let both fall down freely (Phys. Bl. 42, 1986, 407-408)? A working model of a historic mysterious clock and several proposals for perpetuamobilia were shown to intrigue the audience. We speculated about playing ball in the orbit and discussed "the sailor's dream in the calm" (to blow his own sailboat forwards). Thermal toys as presented in the lecture are either heat engines operating on a small temperature difference or thermoacoustic oscillators exerting self-sustained vibrations: the candle seesaw, the putt-putt boats, the "thermobile", the drinking duck, the Christmas turbine, the singing chimney (Rijke tube). Various thermal processes are realized in their mechanisms, e.g. thermal convection, heat transfer and phase transitions.

Section: Rheology

P.K. CURRIE

Static Shear Layers in Nematic Liquid

In work done together with F.M. Leslie, an attempt has been made to provide an explanation of certain experimental observations concerning layers of nematic liquid crystals that can sustain a shear stress without deformation. Until these observations were made, it was generally accepted that a nematic liquid crystal could not sustain shear stress without flowing. We have considered a somewhat less complex situation than in the experiments, confining attention to a static nematic layer bounded by parallel plates. For this simpler problem it proves possible to demonstrate a mechanism whereby a static layer can sustain a shear stress, the effect arising from arrays of line disclinations (singularities in the orientation) anchored to the bounding plates.

Th. ALTS

Boundary-Layer Theory of Curved Phase Interfaces

Real phase interfaces are thin boundary-layers across which all bulk fields experience smooth though rapid changes. This is modelled by a new boundary-layer theory for curved phase boundaries in non-equilibrium. Comparison with the theory of singular surfaces allows physical interpretation of the surface fields in terms of mean values of bulk fields, but it also requires satisfaction of dynamical consistency conditions for tangential momentum and surface stress. These yield new results for the curvature dependence of surface tension, for phase-change processes across the interface and for the dynamics of nucleation. A stability analysis proves the impossibility of certain nuclei.

An outline of the theory for ice/water interfaces is given and some predictions on nuclei formation and on the phenomena of undercooling and superheating are presented.

R. RYDZEWSKI

The Field Equations of a Liquid Containing Small Gas Bubbles

A suspension consisting of an incompressible, inviscid liquid and of ideal gas bubbles is considered on a microscopic and on a continuum mechanical level. From a miscroscopic formulation of mass conservation of both the liquid and the gas the continuum mechanical partial mass balance equations are derived. The equation of motion of a single bubble is established by use of potential theory of fluid mechanics; averaging it for all bubbles in the vicinity of a point of interest gives the continuum mechanical balance equations for the mean momentum of the bubbles. Averaging the Bernoulli equation for the liquid in the vicinity of a point of interest gives the balance equation for the mean momentum of the liquid. In both of these partial momentum balance equations there occur terms in the partial stress tensor and in the partial momentum production respectively, which do not satisfy the principle of material frame indifference. Finally the propagation of plane harmonic sound waves in the suspension is considered as a specific solution of the field equations. Phase velocity and attenuation as functions of frequency are calculated.

A. MORRO

Drag Force and Conservation Laws in Fluid Dynamics

The possible acceleration dependence of the drag on a sphere, executing a translatory motion in a fluid, is examined in detail. After revisiting the standard derivations of this dependence, it is pointed out that the result might be connected with the scheme of incompressible fluids. That the adoption of this scheme is crucial is made evident by showing that a striking contradiction would arise in compressible fluids. Next, a procedure is applied which, in a suitable linear approximation, leads to an explicit expression for the drag in compressible fluids. The drag turns out to depend both on the present value and on the history of the speed of the sphere. Finally it is pointed out that improvements are likely to occur, if new conservations laws are considered which arise from a general formulation of Noether's theorem.

Y.A. BEREZIN

Convection, Gyrotropic Turbulence and the Large Structures in Fluids

Large-scale convective motions in the presence of developed small-scale turbulence are studied. The turbulence is isotropic, homogeneous, gyrotropic i.e. $\langle \underline{v}^T \cdot \mathrm{rot}\, \underline{v}^T \rangle \neq 0$, $\underline{v}^T$ is the small-scale turbulent velocity field. The turbulent characteristics are assumed to be given.

Linear analysis of the governing equations consisting of the equations of an incompressible fluid in the Boussinesq approximation with additional gyrotropic term reveals the existence of neutral stability curves of two different types. Analysis of the curves and corresponding solutions for the horizontal layer heated from below are given.

F.M. LESLIE

Continuum Theory for Biaxial Nematics

The aim is to give an account of continuum theory for biaxial nematic liquid crystals outlining the particular equations likely to describe flow effects and equilibrium configurations in static magnetic fields. My starting point is a derivation of balance laws based upon the conservation principles of linear and angular momentum, essentially a generalisation of the equations proposed by Ericksen for uniaxial liquid crystals. There follows a discussion of constitutive equations needed to describe flow alignment in the bulk, where one again finds that the dynamic couple stress is zero but the stress tensor is more complex than for a uniaxial nematic. The latter part of the talk derives equilibrium theory for biaxial nematics extending Ericksen's formulation for a uniaxial nematic based on a principle of virtual work and presents some preliminary calculations of Friedrich's transitions for biaxial nematics.

S. HESS

Non-Newtonian Viscosity and Normal Pressure Differences: Phenomena and Microscopic Explanations

The transport coefficients characterizing the flow behaviour of a fluid are introduced and specified for a plane Couette (simple shear) flow. The pressure tensor is a sum of contributions involving integrals over the velocity distribution function, the pair-correlation function and, for molecular fluids, an orientational distribution. As a consequence, the viscosity coefficients are also given by a corresponding sum. The kinetic theory calculation starts from kinetic equations for the various distribution functions which are the Boltzmann equation, the Kirkwood-Smoluchowski equation and a Fokker-Planck equation. Results obtained from kinetic theory are compared with non-equilibrium molecular dynamics simulations for gases, dense fluids of spherical particles and for polymeric liquids.

Ph. THOMPSON

Fast Adiabatic Waves with Phase Changes

Wavelike phase changes in a variety of liquid-vapour systems are described. Phenomena of interest include liquefaction shock waves, cavitation, single-phase and multiphase rarefaction shocks, liquid-evaporation waves, different forms of wave splitting, critical supersaturation and near-critical discontinuities. Very recent results for shock stability in iso-octane are shown, in which an initially stable shockfront passes through the following stages with increasing shock Mach number: Stable, unstable, stable, unstable, over a range M_s = 1.86 to 3.22. Some results for non-equilibrium, near-critical states are shown.

H. BUGGISCH

Zur Rheologie granularer Medien

Beispiele für granulare Medien sind Sand, Schnee, pulverförmige Produkte der Industrie sowie landwirtschaftliche Produkte. Die "Rheologie" solcher Medien versucht, deren Fließverhalten mit mathematischen Gleichungen zu beschreiben.

In diesem Beitrag wird die Bewegung des Granulats als "turbulente" Strömung eines inhomogenen Kontinuums angesehen. Durch Ensemble-Mittelwertbildung der mikroskopischen Gleichungen der Kontinuums Mechanik werden Bilanzgleichungen für gemittelte Feldgrößen hergeleitet. Der Zusammenhang dieser Gleichungen mit aus der Literatur bekannten auf der Basis von "kinetischen" Theorien gewonnenen Gleichungen wird diskutiert.

Eine neue Materialgleichung, welche bei einfacher stationärer Scherung den Zusammenhang zwischen Scherrate (Schergeschwindigkeit), Schubspannung und Normalspannung beschreibt, wird vorgeschlagen. Theoretische Vorhersagen werden mit experimentellen Ergebnissen verglichen.

Section: Waves

F. VIDAL & J. MAZA

Local and Average Velocity in a Critical Inhomogenous Sample

In the neighbourhood of a continuous transition of a phase, when there is also an external field the system can develop substantial gradients. In this case, the measured velocity is also an average of the local (theoretical) velocity.

The same occurs when the system presents some more intrinsic inhomogeneity, an example of which is a binary mixture. Under the constraint of weak inhomogeneity we have presented the relation linking the local and average velocity. The ultimate goal is to obtain the local velocity (from which substantial information can be obtained) from the rounded (measured) velocity.

K. HUTTER

The Motion of a Finite Mass of Gravel Down a Rough Incline

Rock, snow or ice avalanches having a finite mass are treated as a granular material satisfying the postulates of a frictional Coulomb-like continuum. Depth-averaged equations of motion for the granular mass and the averaged longitudinal velocity are derived; they bear a superficial resemblance to the non-linear shallow water equations. Two similarity solutions are found, one having the shape of a parabolic cap, the other the form of a M-wave. The first is found to be unstable against small perturbations; a restricted stability analysis of the second shows it to be stable. Numerical solutions of the governing equations, which are based on a finite difference approximation using McCormack's upwind differences plus additional numerical diffusion, are presented and shown to approach the M-wave similarity solution at large times. The numerical predictions are compared with laboratory experiments involving the motions of gravel released from rest on a rough inclined plane. Agreement between theoretical prediction and experiments is satisfactory. Possible improvements of the theory and extensions are discussed.

M. HAYES

Inhomogenous Plane Wave Solutions in Mechanics and Optics

Elliptically polarized time harmonic inhomogenous plane waves occur in many areas. For example, the classical Rayleigh surface wave is a combination of two such waves. Gravity waves in ideal fluid flow, Love and Stoneley waves in solids, electromagnetic, TE and TM waves are all formed by combinations of these waves. Using bivectors (or complex vectors) a simple direct treatment of inhomogenous waves is possible. In particular, the conditions for circularly polarized inhomogenous waves are obtained. Applications are made to anisotropic linearly elastic solids, viscoelastic solids and to electrically anisotropic crystals.

G. BOILLAT

On Shock Velocity Considered as Eigenvalue

While wave fronts are characteristic surfaces so that wave velocities appear as eigenvalues of some matrix depending on the fields, shock waves

generally behave in quite a different way.
However, it is possible to consider shock velocities as eigenvalues of a mean value matrix which depends on the state before and after the shock. The gradient of this eigenvalue with respect to one of these states generates the jump of the main field. Multiple eigenvalues which correspond to the "exceptional" (but very common) case are also considered.

A.M. ANILE

Propagation and Stability of Shock Waves

A formal justification is provided for Whitham's characteristic rule and geometrical shock dynamics starting from the equations of gasdynamics. The justification is based on the theory of propagating singular surfaces and on the analysis of the initial value problem for discontinuous solutions. The concept of steep shock of order n is introduced for this purpose. The resulting theory is compared with Whitham's one and agrees with it in many cases. In other instances there is a small discrepancy whose significance is not completely clear.

As a byproduct of the theory we obtain an exact stability result for the corrugation stability of a plane fronted shock.

Section: Viscoelasticity/Plasticity

F. MAINARDI

The Damping of Surface Waves in Viscous Liquids

The behaviour of small amplitude waves on the plane surface of a layer of a viscous liquid is derived from the appropriate dispersion relation between the real wave number and the complex frequency. Explicit numerical results are presented for the dispersion properties in some illustrative cases. Asymptotic expressions obtained analytically are used to check the numerical results.

Limits to propagation are found for both short and long waves. The wavelength range of propagation gradually decreases with decreasing the depth of the layer, so that for any liquid, a critical depth is found below which wave propagation cannot take place.

H. LIPPMANN

On Plastic Strain Localization

In a plastically pre-strained solid a certain type of instability may occur at which the plastified volume reduces so that plastic deformation localizes to a smaller region, while the remaining part of the body falls back into an elastic state. The onset of this localization process is usually treated by means of bifurcation theory. In the present lecture an older approach due to Considère (1885) is re-established, and generalized in a way that it delivers under certain conditions, a sufficient and necessary criterion. It is illustrated at the (well known) examples of uniaxial necking of a metal rod, and of deformation bands in thin metal strips. An actual non-classical application arises when so-called dead metal zones are considered at the process of metal extrusion from a block container with rectangular axial section.

Section: Elasticity

T. ATANACKOVIC

In this presentation we studied stability of a thin elastic rod that is rotating with constant angular velocity about its axis and is loaded with concentrated force at its end.

Two types of imperfections are assumed to be present. The shape imperfections are characterized by an initial deformation while load imperfections are characterized by a concentrated force perpendicular to the axis of rotation. Using singularity theory the stability of the rod is determined for increasing and decreasing angular velocity of rotation.

Z. WESOLOWSKI

Directional Invariance of a Set of Elastic Layers

A plane sinusoidal wave propagates perpendicular to a set of elastic layers. At the boundaries between the layers both the displacements and stresses are continuous. The incident wave produces the reflected and transmitted waves. The reflected wave depends essentially on the ordering of the layers. It has been proved that in contrast to this the transmitted wave is invariant under shuffling of the layers.

Section: Martensitic Transformations

F. FALK

Motion of Domain Walls in Shape Memory Alloys

Based on a one-dimensional model for the martensitic phase transition in shape memory alloys, domain walls in those systems are treated as transverse shock waves across which the shear strain jumps. The motion of the domain walls is determined by the balance of momentum and energy. In order to evaluate the balance equations constitutive relations following from Landau theory of phase transitions are adopted. Furthermore, internal friction is included. From the balance equations and the constitutive relations only the value of the speed of the domain walls follow. The direction of motion is determined by the Second Law of thermodynamics. In the case of an austenite-martensite wall, due to the thermodynamic driving force, there may be a mechanical power output against external surface forces .

J. SPREKELS

Existence, Uniqueness and Optimal Control of Phase Transitions in Shape Memory Alloys

The coupled nonlinear system

$$u_{tt} - (\psi_\varepsilon(\varepsilon.\theta))_x - \mu u_{xxt} = f$$

$$- \theta\ (\psi_\theta(\varepsilon,\theta))_t - k_1\theta_{xx} - k_2\theta_{xxt} - \mu u^2{}_{xt} = \lambda \quad ,$$

together with appropriate initial and boundary conditions, constitutes a regularized version for the one dimensional model equations governing martensitic phase transitions in shape memory alloys. Assuming the free energy ψ for small $|\varepsilon|$ in the Landau-Devonshire form, we can prove the unique existence of a weak solution. Continuous dependence on the data (f,λ) is shown, and for a related problem of optimal control we establish the existence of optimal controls and necessary conditions of optimality. For the unregularized system ($\mu = k_2 = 0$), numerical calculations are presented in form of a coloured computer graphics movie.

Section: Thermodynamics

G. CAPRIZ

Continua with General Microstructure

The element of a continuum body B with microstructure is thought as a Lagrangean system; the coordinates are: the coordinates z of the element and a finite number of order parameters ν^α. These latter are coordinates in a local chart of an element $\underset{\sim}{\nu}$ of a differential manifold M (as in the topological theory of defects). In a process for B, z and $\underset{\sim}{\nu}$ are funtions of time and the choice of the ν^α must be made in such a way that: (i) the extra kinetic energy due to the microstructure goes to zero as $\dot{\underset{\sim}{\nu}}$ goes to zero; (ii) the power of microstresses is linear in $\dot{\underset{\sim}{\nu}}$, grad $\dot{\underset{\sim}{\nu}}$. Then the values of ν^α depend on the observer, in general, and so we must know the effect of a change of observer on $\underset{\sim}{\nu}$: i.e. one must define the action of the orthogonal group on M, $\underset{\sim}{\nu} \overset{q}{\rightarrow} \underset{\sim}{\nu}_{(q)}$ and the infintesimal generator a, such that $\underset{\sim}{\nu}_{(q)} = \underset{\sim}{\nu} + a\,q + 0\,(q)$, where q is the vector of rotation. These are the premisses for a study of the dynamics of continua with any type of microstructure, in particular of (compressible or incompressible) fluids with microstructure. A typical result is an expression for the so-called Ericksen stress, introduced in the study of liquid crystals, but in fact present in general in such fluids.

M. SILHAVY

Admissibility Criteria for Shocks and Propagating Phase Boundaries

Weak solutions of the equations of motion of an elastic, inviscid isothermal fluid contain surfaces of discontinuity of specific volume which can be interpreted either as shock waves or as propagating phase boundaries separating the liquid and vapour phases of the fluid. By approximating the discontinuities of the fluid by smooth profiles of a non-elastic fluid in which the pressure depends on the gradients of specific volume and on a number of internal parameters the author has shown in a previous paper that each jump has to satisfy certain inequality. This inequality can play the role of an admissibility criterion for selecting proper jumps from the physically meaningful ones. In regions where the pressure is a decreasing, convex function of specific volume the inequality leads to the results as the admissibility criteria proposed earlier. However, in contrast to the criteria proposed earlier, the present inequality allows jumps which describe dynamic phase transitions with the specific volumes near the specific volumes of the statically coexistent phases of the fluid.

Section: Thermodynamics and Kinetic Theory

E.G.D. COHEN

Thermodynamics and Dynamics on the Molecular Level for Simple Fluids

The five linear moment equations of Grad for a dilute gas are considered first in the case of longitudinal deviations from equilibrium. Written in matrix form, the matrix has a structure with all off-diagonal elements, that are non-zero, proportional to ik and the only two nonvanishing diagonal elements, which correspond to the zz-component of the pressure tensor and the z-component of the heat flux vector are non-zero. Symmetrizing this matrix leads to 5 eigenmodes, where the eigenvalues can be compared with those of a linear Navier-Stokes hydrodynamics as well as with the 5 lowest moments of a 55-moment calculation. The eigenmodes appear to be reliable to values of $kl_o = 0.2$ ($\lambda = 30\ l_o$), where l_o is the mean free path.

Next, the 25 time correlation functions of the fluctuations of the same 5 longitudinal quantities are considered. The exact matrix, which gives the time evaluation of these correlation functions, has the same form as that for the dilute gas. In the approximation that the matrix does not depend on frequency, but only on wave number, it has the same structure as that of a dilute gas, when $k \to 0$. The matrix elements and eigenmodes have been derived for a 12 - 6 Lennard-Jones fluid from computer simulations. The question of the applicability of this matrix - determined from fluctuation - to problems on the macroscopic level is not completely clear. The appearance of k-dependent thermodynamic quantities, which reduce to the usual ones when $k \to 0$ is discussed.

Ingo MUELLER

Extended Thermodynamics of Relativistic Gases

Extended thermodynamics has the objective of determining the 14 fields of N^A, the particle flux vector, and T^{AB}, the energy momentum tensor. The corresponding field equations are based upon the conservation laws of particle number and of energy momentum and upon the balance of fluxes. Constitutive equations are needed for the flux tensor and its production. The constitutive functions are restricted by the entropy principle, the principle of relativity and the requirement of hyperbolicity. These restrictive conditions succeed in determining all constitutive coefficients, if only the thermal equation of state is known. That equation can be either measured or determined from equilibrium statistical thermodynamics. This latter procedure requires the knowledge of the distribution function of molecular momenta for relativistic and possibly degenerate gases, the Jüttner distribution . Various limiting cases are discussed: the non-relativistic, non-degenerate case, the ultrarelativistic and strongly degenerate case of Bose particles, and the non-relativistic degenerate case appropriate for Bosons and Fermions.

W. DREYER

Maximization of Entropy in Non-Equilibrium

The maximization of entropy in non-equilibrium leads to constitutive functions for degenerate gases which satisfy the entropy inequality identically. This is an extension to non-equilibrium of Boltzmann's method, by which the phase density f in equilibrium can be obtained by maximising the entropy under the constraints of fixed mass density, momentum density and internal energy density.

In non-equilibrium further moments of f contribute to the state of the gas. It is proved for degenerate ideal gases that the exploitation of the entropy inequality and the maximization of the entropy itself leads to the same results as follows: The well-known Lagrange multipliers of the kinetic theory turn out to be identical to the Lagrange multipliers of the phenomenological theory that were utilized in the evaluation of the entropy inequality.

W. WEISS

Signal Velocities and Extended Thermodynamics

Extended thermodynamics in its simplest form is a field theory which considers as basic variables mass density, momentum density, energy density, pressure deviator and heat flux.

This goes beyond ordinary thermodynamics in which the state of a gas (say) is only described by the five fields mass density, momentum density, energy density.
The decision what the appropriate number of variables is has to be determined by experiments. Intuitively one feels the more a process is far from equilibrium the more variables are needed. In the talk I have dealt with the influence of higher moments up to the number 85 in order to study the propagation of initial disturbances in mass density and pressure. In particular the velocity of the fastest disturbance has been calculated. It has come out that this velocity increases with increasing number of variables (moments). Comparison with experiments leads to the conclusion that even more than 85 moments have to be taken into account in order to fit the experimental data.

G.M. KREMER

Kinetic Theory of Polyatomic Gases

A kinetic theory for a polyatomic gas consisting of perfectly rough, elastic and rigid spherical molecules is developed. A macroscopic state is characterized by 29 scalar fields of density, velocity, pressure tensor, temperature, translational heat flux, rotational heat flux, spin and spin flux.

For the case of a rarefied gas, the propagation of plane harmonic waves of small amplitude is investigated. For the case of a dense gas, the constitutive equations for the pressure tensor, heat flux and spin flux obtained through an iteration method, can be identified with those of a polar fluid.

T. RUGGERI

Hyperbolicity and Wave Propagation in Extended Thermodynamics

Some mathematical problems related to hyperbolicity and wave propagation in Extended Thermodynamics are presented.
In particular we investigate the Cauchy problem for Bose- and Fermi-gases. The critical time concerning the blowup of the solution is estimated for a classical fluid.
Finally some perspectives on superfluidity are presented.

C. CERCIGNANI

Wave Propagation According to a Kinetic Model for an Ultrarelativistic Gas

A model of the Boltzmann equation for a relativistic gas, proposed by Anderson and Witting in 1974, is applied to the study of small perturbations of equilibrium. In particular, it is shown that in the ultrarelativistic limit and for (1+1)-dimensional problems the model is reducible to solving a system of three uncoupled equations, one of which is well-known. A general method for solving these equations is recalled with a few new details and applied to the solution of two boundary value problems. The first of these describes the propagation of an impulsive change in a half space and is shown to give an explicit example of the result that no signal can propagate with a speed larger than the light speed in relativistic kinetic theory. The second problem deals with steady oscillations in a half space and illustrates the meaning of certain recent results concerning the dispersion relation for linear waves in a relativistic gas. The more complex equation describing the propagation of sound waves is also briefly discussed.

K. WILMANSKI

Extended Thermodynamics of a Maxwell-Type Fluid

I consider thermodynamic restrictions for a rate-type model of a non-newtonian fluid. Both the deviatoric part of the stress and the heat flux are supposed to satisfy the rate equations. It is shown that the normal stress coefficients α_1 and α_2 satisfy the conditions $\alpha_1 < 0$, $\alpha_2 = -\alpha_1$. The last condition contradicts the experimental data and can be corrected by replacing the rate equations by appropriate balance equations as implied by extended thermodynamics.

K. SUCHY

Pressure Tensor in Strongly Magnetized Media

In a magnetized fluid the heat conductivity belongs to a special type of 2nd-rank tensors, called "cyclotonics" by Gibbs, whose eigenvector and three projectors $\underset{\sim}{p}_m(\hat{b})$ $(m = 0, \pm 1)$ depend merely on the direction $\hat{b}$ of the magnetic field. The viscosity is a double-symmetric 4th-rank cyclotonic. The 6 projections of the 4th-rank cyclotonics and their eigentensors are constructed from the three $\underset{\sim}{p}_m$. Four of them are double-tracefree, the other 2 are decomposed into tracefree tracefree, tracefree isotropic isotropic tracefree, and isotropic isotropic parts. For tracefree stress tensors (as in dilute gases and plasmas) the viscosity tensor has 5 projectors constructed from the three $\underset{\sim}{p}_m$. With these 5 projectors the stress evolution equation is solved and the viscosity tensor is represented exactly in 5 terms of increasing order in the strength of the magnetic field.

M. GRMELA

Why are Bracket Formulations Useful: Multilevel Description of Fluids

Can dynamical equations arising in nonequilibrium statistical mechanics be formulated in such a way that they become manifestly compatible with equilibrium thermodynamics? The formulation that uses generalized Poison brackets answers this question affirmatively. The unifying bracket formulation is found for example for the Boltzmann and the Enskog kinetic equations and for the Navier-Stokes-Fourier hydrodynamic equations. As an example we consider the following problem: Let a family of candidates for the time evolution equations be given. We want to narrow down the family by retaining only the time evolution equations that are compatible with equilibrium thermodynamics (i.e. solutions of these equations reflect the experience expressed in equilibrium thermodynamics). Using the bracket formulation as the mathematical expression of the compatablity with equilibrium thermodynamics, we retain only those that admit the bracket formulation. This strategy is applied to the BBGKY hierarchy, the Maxwell-Grad hierarchy and the governing equations of generalized hydrodynamics. The results obtained in the context of generalized hydrodynamics are applied to the study of equilibrium and rheological properties of polymeric liquid crystals.

Berichterstatter: W. Dreyer

Tagungsteilnehmer

Prof. Dr. Th. Alts

Institut für Theorie der
Kondensierten Materie, F.U.Berlin
Arnimallee 14

1000 B e r l i n 33

Prof. Dr. W. Bürger

Institut für Theor. Mechanik
Universität Karlsruhe
Englerstr. 2

7500 K a r l s r u h e

Prof. Dr. A. M. Anile

Dipartimento di Matematica
Cittá Universitaria
Viale A. Doria 6

95125 C a t a n i a / Italien

Prof. Dr. H. Buggisch

Institut für Mech. Verfahrens-
technik u. Mechanik der Uni
Postfach 6380

7500 K a r l s r u h e 1

Prof. Dr. T. Atanackovic

Faculty of Technical Sciences
V. Vlahovica 3

21000 N o v i S a d
Jugoslawien

Prof. Dr. G. Capriz

c/o TECSIEL
Via S. Maria 19

56100 P i s a
Italien

Prof. Dr. Yu. A. Berezin

Institute of Theoretical and
Applied Mechanics

630 090 Novosibirsk 90
Sowjetunion

Prof. Dr. C. Cercignani

Dipartimento di Matematica
Politecnico di Milano
Piazza L. da Vinci, 32

20133 M i l a n o
Italien

Peter Blos

Institut für Theor. Mechanik
Universität Karlsruhe
Kaiserstr. 12

7500 K a r l s r u h e 1

Prof. Dr. E.G.D. Cohen

The Rockefeller University
1230 York Avenue

N e w Y o r k , N.Y. 10021
U S A

Prof. Dr. G. Boillat

Dépt. de Mathématique
Université de Clermont
B. P. 45

63170 A u b i è r e
Frankreich

Dr. P. K. Currie

Guldeland 103

2291 VJ W a t e r i n g e n
Niederlande

Dr. W. Dreyer

Hermann Föttinger Institut
T. U. Berlin; FB 9
Strasse des 17. Juni 135

1000 B e r l i n 12

Dr. F. Falk

FB Physik
Universität-GH-Paderborn
Warburger Str. 100

4790 P a d e r b o r n

Prof. Dr. M. Grmela

Ecole Polytechnique de Montreal
Case Postale 6079

M o n t r e a l H3C 3A7
Canada

Prof. Dr. M. Hayes

Mathematical Physics
University College
Belfield

D u b l i n 4 / Irland

Prof. Dr. S. Hess

Technische Universität Berlin
Institut für Theor. Physik
Sekr. PN 7-1
Hardenbergstr. 36

1000 B e r l i n 12

Dr. K. Hutter

Versuchsanstalt für Wasserbau
Gloriastr. 37

8092 Z ü r i c h
Schweiz

Dr. G. M. Kremer

Departamento de Fisica
Universidade Federal do Paraná
Caixa Postal 19081

81.504 C u r i t i b a
Brasilien

Prof. Dr. F. M. Leslie

Department of Mathematics
University of Strathclyde
Livingstone Tower,26 Richmond St.

G l a s g o w G1 1XH
Schottland

Prof. Dr. H. Lippmann

Lehrstuhl A für Mechanik
Technische Universität
Postfach 20 24 20

8000 M ü n c h e n 2

Prof. Dr. F. Mainardi

Department of Physics
University of Bologna
Via Irnerio, 46

40126 B o l o g n a / Italien

Prof. Dr. J. Maza

Laboratorio de Fisica de Mat.
Facultad de Fisica, Universidad
de Santiago de Compostela

Santiago de Compostela / Spanien

Prof. Dr. A. Morro

Dipartimento di Ingegneria Bio-
fisica ed Elettronica
Viale F. Causa 13

16145 G e n o v a / Italien

Prof. Dr. I. Müller

Hermann-Föttinger-Institut
FB 9 - T. U. Berlin
Straße des 17. Juni 135

1000 B e r l i n 12

Prof. Dr. T. Ruggeri

Dipartimento di Matematica
Università di Bologna
Sede stallata di Via Vallescura

40136 B o l o g n a / Italien

Dipl.-Ing. R. Rydzewski
Technische Universität Berlin
Herrmann Föttinger Institut
Straße des 17. Juni 135
1000 Berlin 12

Prof. Dr. J. Schröter
Universität Paderborn
Theoretische Physik, FB 6
N 3.338 - Warburger Str. 100
4790 Paderborn

Dipl.-Phys. S. Schwarz
Institut für Theor. Mechanik
Universität Karlsruhe
Kaiserstr. 12
7500 Karlsruhe 1

Dr. M. Silhavý
Mathematical Institute, CSAV
Zitná 25
115 67 Praha 1
Tschechoslowakei

Prof. Dr. J. Sprekels
Institut für Mathematik der
Universität Augsburg
Memminger Str. 6
8900 Augsburg

Prof. Dr. K. Suchy
Institut für Theor. Physik (II)
Universität Düsseldorf
Universitätsstr. 1
4000 Düsseldorf 1

Prof. Dr. Ph. A. Thompson
Mechanical Engineering
Rensselaer Polytechnic Institute
Troy, N.Y. 12180-3590
USA

Prof. Dr. W. von Wahl
Lehrstuhl für Angew. Mathematik
Universität Bayreuth
Postfach 10 12 51
8580 Bayreuth

Dipl.-Ing. W. Weiss
Hermann Föttinger Institut
T. U. Berlin - FB 9
Straße des 17. Juni 135
1000 Berlin 12

Prof. Dr. Z. Wesolowski
Inst. Fundamental Technol. Res.
Swietokrzyska 21
00-049 Warsaw
Polen

Prof. Dr. K. Wilmanski
Breslauer Str. 15
4792 Bad Lippspringe

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