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ABSTRACT

It is shown that, in the low temperature limit, the effective medium approximation predicts a universal frequency-dependence of the conductivity of non-metallic disordered solids. The calculation is based on a macroscopic approach to AC conduction and is valid in more than one dimension. The universality prediction is confirmed by simulations in two dimensions.

For many years AC conduction has been studied in disordered solids like amorphous semiconductors, glasses, polymers, nonstoichiometric solids, or metal-cluster compounds [1-8]. All disordered solids show similar AC behavior, whether the conduction is electronic, polaronic, or ionic. The frequency-dependent conductivity follows an approximate power-law with an exponent between 0.7 and 1.0 . At lower frequencies there is a gradual transition to constant conductivity. The standard models for this are hopping models which deal with the random walk of non-interacting charge carriers in a random environment [9-13]. While hopping models are rather successful, the importance of Coulomb interactions has recently come into focus [14,15]. Maass and coworkers have shown that the Coulomb repulsion may have significant effect on the frequency-dependence of certain hopping models [15]. Unfortunately, hopping models with interactions are not amenable to simple analytic treatment. One way to include the effect of Coulomb interactions between charge carriers is to, instead of using hopping models, adopt a macroscopic point of view [16-19]. This is done here where conduction in inhomogeneous media is discussed by exploring Maxwell's equations.

Consider a solid with spatially varying thermally activated conductivity $g(\boldsymbol{r}) = g_0 e^{-\beta E(\boldsymbol{r})}$. Here β is the inverse temperature and the activation energy $E(\boldsymbol{r})$ is assumed to vary randomly in space with a finite correlation length. If ϵ denotes the dielectric constant and ω the angular frequency, the continuity equation and Gauss' law imply

for the electrostatic potential ϕ

$$\nabla\cdot\left(\left(i\omega\epsilon+g\right)\nabla\phi\right)=0. \qquad (1)$$

This equation is discretized [20,21] by regarding the potential ϕ as defined on the points of a simple cubic lattice and the quantity $i\omega\epsilon+g$ as defined on nearest neighbor links. In this way Eq. (1) becomes the Kirchhoff current conservation law for a lattice where each link is a resistor in parallel with a capacitor. If a is the lattice constant and D the dimension, the correct continuum limit is ensured if each link admittance y is given by

$$y=a^{D-2}\left(i\omega\epsilon+g\right) \quad . \qquad (2)$$

The circuit is not to be interpreted literally as a physical model of the solid because the real physical currents run through the resistors only. However, the circuit is useful for calculating the macroscopic frequency-dependent conductivity $\sigma(\omega)$, i. e., the ratio between average current and average electrical field. If L is the linear circuit dimension and $G(\omega)$ is the admittance between opposing faces, it is straightforward to show that, whenever ϵ is space-independent, $\sigma(\omega)$ is given [22] by

$$\sigma(\omega)=\frac{G(\omega)}{L^{D-2}}-i\omega\epsilon \quad . \qquad (3)$$

If the discretization length a is chosen to be the correlation length for $E(\boldsymbol{r})$ and correlations beyond a are ignored [20,23], the effective medium approximation (EMA) may be applied to calculate G [16,20]. The EMA equation for the effective link admittance, y_m, is $\langle (y-y_m)/[y+(D-1)y_m] \rangle_y = 0$. Since $G=N^{D-2}y_m$ where $N=L/a$, the EMA equation and Eqs. (2) and (3) imply (where $s \equiv i\omega\epsilon$ is the Laplace frequency)

$$\frac{1}{D(\sigma+s)} = \left\langle \frac{1}{g(E)+(D-1)\sigma+Ds} \right\rangle_E . \qquad (4)$$

This equation has a simple solution in the limit $\beta \to \infty$. The root $E=E_g(s)$ of $g(E)=(D-1)\sigma+Ds$ is given by

$$E_g(s) = -\frac{1}{\beta} \ln\left(\frac{(D-1)\sigma+Ds}{g_0}\right) . \qquad (5)$$

If $p(E)$ is the activation energy probability distribution, Eq. (4) at low temperatures becomes

$$\frac{1}{D(\sigma+s)} = \frac{1}{(D-1)\sigma+Ds} \int_{E_g(s)}^{\infty} p(E)\,dE , \qquad (6)$$

or

$$\frac{D-1}{D} + \frac{s}{D(\sigma+s)} = \int_{E_g(s)}^{\infty} p(E)\,dE . \qquad (7)$$

For large β subtracting the $s=0$ case of Eq. (7) from Eq. (7) itself leads to

$$\frac{s}{D(\sigma+s)} = \int_{E_g(s)}^{E_g(0)} p(E)\,dE = p(E_g(0))\,\frac{1}{\beta}\ln\left(\frac{\sigma}{\sigma(0)}+\frac{D}{D-1}\,\frac{s}{\sigma(0)}\right) \quad . \tag{8}$$

Introducing the dimensionless variables

$$\tilde{\sigma} = \frac{\sigma}{\sigma(0)} \quad , \quad \tilde{s} = \frac{\beta}{D\,p(E_g(0))\,\sigma(0)}\,s \quad , \tag{9}$$

Eq. (8) for $\beta\to\infty$ reduces to

$$\tilde{\sigma}\,\ln(\tilde{\sigma}) = \tilde{s} \quad . \tag{10}$$

Equation (10) was derived by Fishchuk for the uniform energy barrier distribution with cut-off's where the average in Eq. (4) can be calculated explicitly [24]. Here it has been shown that, in the low temperature limit, the EMA predicts a universal frequency-dependence of the conductivity (in any dimension $D>1$). There is, however, some doubt whether the EMA is reliable for systems with extremely broad distributions of admittances [25,26]. Therefore, computer simulations were carried out to test Eq. (10). At low temperatures large lattices are needed to obtain reasonable statistics, and the simulations are quite demanding. Only the two-dimensional case was studied where the highly efficient Frank-Lobb algorithm is available [27]. For simplicity the simulations were carried out for real $\tilde{s}$. Several different activation energy distri-

butions were used. The results are shown in Fig. 1. They confirm the EMA prediction of universality as the temperature is lowered. The universality represents a new type of regularity, appearing gradually as the "relaxation time distribution" becomes extremely broad. The universality is not a consequence of a diverging correlation length, as for a second order phase transition, and there are no critical exponents.

The EMA equation (10) was first derived by Bryksin for a model of non-interacting electrons tunneling between positionally disordered sites [28]; it has also been shown to apply for a hopping model with a box type distribution of energy barriers [5]. Hopping models are neither physically nor mathematically equivalent to the macroscopic approach taken here. But both types of models lead to large sparse matrix equations expressing local current conservation. It is likely that, in the limit of severe disorder, the EMA for any problem of this type leads to Eq. (10) for the frequency-dependent conductivity (or diffusion constant).

An important and well established experimental fact is the Barton-Nakajima-Namikawa (BNN) relation [29-31], i. e. , the rule that the characteristic frequency for onset of AC conduction has the same activation energy as $\sigma(0)$ [32]. This follows directly from Eqs. (9) and (10) (a reduced frequency definition similar to Eq. (9) was used for hopping models by Scher and Lax [33] and by Summerfield [34]). It is easy to understand qualitatively why the BNN relation is valid here. In the DC limit the current follows the "critical" percolation paths giving the easiest ways between the electrodes [35]. As

the frequency increases there is little effect until, for $s \sim s_c$, s is of order the lowest admittance y_{min} met on a critical path. On the other hand, the DC conductivity is also determined by y_{min} [35,36], and thus one expects $\sigma(0) \sim s_c$ which is the essence of the BNN relation.

In three dimensions the EMA has the percolation threshold somewhat wrong [20], so the predicted DC conductivity activation energy is also wrong. However, Eq. (10) may still be valid in three dimensions at low temperatures. Summerfield has conjectured a "quasi-universality" for the frequency-dependence of the conductivity [34]. This idea fits nicely into the present work that predicts true universality only in the zero temperature limit. Comparing to experiments, it has been shown elsewhere [5] that all qualitative features of experiment follow the equation

$$\tilde{\sigma} = \frac{\tilde{s}}{\ln(1+\tilde{s})} \quad . \tag{11}$$

Equation (11), which clearly is an approximate solution of Eq. (10), represents the admittance along a critical path [22], . Both equations predict an approximate power-law frequency-dependence of the real part of the conductivity where the exponent at the real frequency $\tilde{\omega}=-i\tilde{s}$ is equal to $1-2/\ln(\tilde{\omega})$ [5,28]. A few decades above the onset of AC conduction, the exponent is predicted to be close to 0.8, in agreement with most experiments. Thus, there are certainly no experimental reasons to reject Eq. (10) as a low temperature limiting

universal frequency-dependence of the conductivity in three dimensions.

Some time ago Pollak and Pike suggested that details of the conduction mechanism should be contained in deviations from linear frequency-dependence of the conductivity [37]. While Eq. (10) predicts proportionality $\tilde{\sigma} \propto \tilde{s}$ for $\tilde{s} \to \infty$, there is a non-trivial frequency-dependence in a very large frequency range. If the predicted universality is indeed valid also in three dimensions, there is little information in a conductivity that follows Eq. (10). It seems therefore that experiments could naturally be interpreted in terms of deviations from Eq. (10), which represents the low temperature fixpoint.

In conclusion, it has been shown that the EMA predicts a universal frequency-dependence of the conductivity for disordered non-metals at low temperatures, and simulations in two dimensions have confirmed the prediction. Since hopping models often also follow Eq. (10), one cannot from AC measurements alone distinguish these two approaches to the modelling of AC conduction in disordered solids.

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FIGURE CAPTION

Log-log plot (base 10) of the dimensionless conductivity $\tilde{\sigma}$ as function of the real dimensionless Laplace frequency $\tilde{s}$ (both quantities defined in Eq. (9)). The full curve is the EMA prediction for the low temperature limit of $\tilde{\sigma}(\tilde{s})$ (Eq. (10)), while the symbols represent simulations in two dimensions for different activation energy distributions at different temperatures. Each point represents the average of 20 simulations of a 100x100 lattice. The total admittance was determined by the Frank-Lobb algorithm [27] and $\tilde{\sigma}$ subsequently found from Eq. (3). Beta is the inverse dimensionless temperature. Results are shown for the following activation energy distributions:

a) $p(E) = \frac{1}{\sqrt{2\pi}} e^{-E^2/2}$ $(-\infty<E<\infty)$ (▲).

b) $p(E) = \frac{1}{2}$ $(-1<E<1)$ (●).

c) $p(E) = \frac{2}{\pi}\frac{1}{1+E^2}$ $(0<E<\infty)$ (Δ).

d) $p(E) = e^{-E}$ $(0<E<\infty)$ (**0**).

e) $p(E) = 2E$ $(0<E<1)$ (+).

In each case the distribution could be thought of realistically as centered around an energy E_0 ; this would give an extra

factor $e^{-\beta E_0}$ to both conductivity and frequency without changing $\tilde{\sigma}$ or $\tilde{S}$. The quantity $E_g(0)$ in Eq. (9) is the DC conductivity activation energy (Eq. (5)) which is easily determined from the fact that the percolation threshold is 1/2 in two dimensions [20,22,35,36].

REFERENCES

1. A. E. Owen, J. Non-Cryst. Solids **25**, 372 (1977).
2. A. Mansingh, Bull. Mater. Sci. (India) **2**, 325 (1980).
3. A. K. Jonscher, "Dielectric Relaxation in Solids" (Chelsea Dielectric Press, London, 1983).
4. M. D. Ingram, Phys. Chem. Glasses **28**, 215 (1987).
5. J. C. Dyre, J. Appl. Phys. **64**, 2456 (1988).
6. C. A. Angell, Chem. Rev. **90**, 523 (1990).
7. S. R. Elliott, "Physics of Amorphous Materials", second edition (Longman, London, 1990).
8. M. P. J. van Staveren, H. B. Brom, and L. J. de Jongh, Phys. Rep. **208**, 1 (1991).
9. M. Lax and T. Odagaki, in "Macroscopic Properties of Disordered Media", edited by R. Burridge (Springer, Berlin, 1982), p. 148.
10. H. Böttger and V. V. Bryksin, "Hopping Conduction in Solids" (Akademie Verlag, Berlin, 1985).
11. J. W. Haus and K. W. Kehr, Phys. Rep. **150**, 263 (1987).
12. G. A. Niklasson, J. Appl. Phys. **62**, R1 (1987).
13. J.-P. Bouchaud and A.Georges, Phys. Rep. **195**, 127 (1990).
14. J. O. Isard, Philos. Mag. B **62**, 139 (1990).
15. P. Maass, J. Petersen, A. Bunde, W. Dieterich, and H. E. Roman, Phys. Rev. Lett. **66**, 52 (1991).
16. R. Landauer, in "Electrical Transport and Optical Properties of Inhomogeneous Media", edited by J. C. Garland and D. B. Tanner (AIP Conference Proceedings No. 40, New York, 1978), p.2.

17. A. H. Clark, Thin Solid Films **108**, 285 (1983).

18. T. Nagatani, J. Appl. Phys. **54**, 5132 (1983).

19. "Impedance Spectroscopy", edited by J. R. Macdonald (Wiley, New York, 1987).

20. S. Kirkpatrick, Rev. Mod. Phys. **45**, 574 (1973).

21. I. Webman, J. Jortner, and M. H. Cohen, Phys. Rev. B **11**, 2885 (1975).

22. J. C. Dyre, in preparation.

23. I. Webman, J. Jortner, and M. H. Cohen, Phys. Rev B **15**, 5712 (1977).

24. I. I. Fishchuk, Phys. Stat. Sol. (a) **93**, 675 (1986).

25. J. Koplik, J. Phys. C **14**, 4821 (1981).

26. S. Tyč and B. I. Halperin, Physica A **157**, 210 (1989).

27. D. J. Frank and C. J. Lobb, Phys. Rev. B **37**, 302 (1988).

28. V. V. Bryksin, Fiz. Tverd. Tela **22**, 2441 (1980) [Sov. Phys. Solid State **22**, 1421 (1980)].

29. J. L. Barton, Verres Réfr. **20**, 328 (1966).

30. T. Nakajima, in "1971 Annual Report, Conference on Electric Insulation and Dielectric Phenomena" (National Academy of Sciences, Washington DC, 1972), p. 168.

31. H. Namikawa, J. Non-Cryst. Solids **18**, 173 (1975).

32. J. C. Dyre, J. Non-Cryst. Solids **88**, 271 (1986).

33. H. Scher and M. Lax, Phys. Rev. B **7**, 4502 (1973).

34. S. Summerfield, Philos. Mag. B **52**, 9 (1985).

35. V. Ambegaokar, B. I. Halperin, and J. S. Langer, Phys. Rev. B **4**, 2612 (1971).

36. D. Berman, B. G. Orr, H. M Jaeger, and A. M. Goldman, Phys. Rev. B **33**, 4301 (1986).

37. M. Pollak and G. E. Pike, Phys. Rev. Lett. 28, 1449 (1972).

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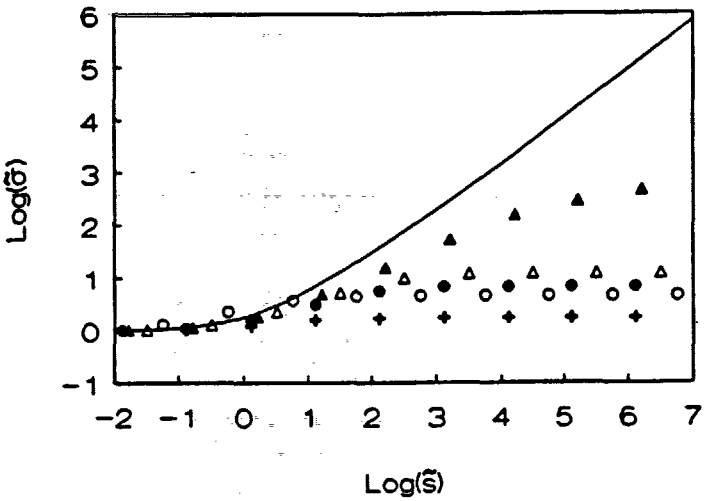

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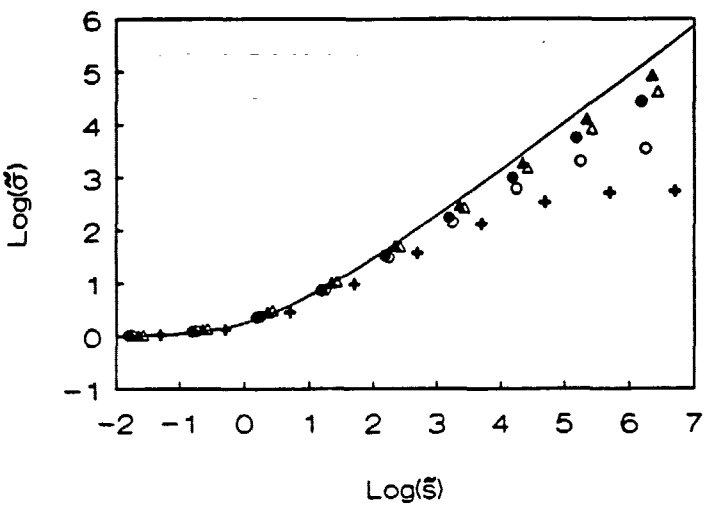

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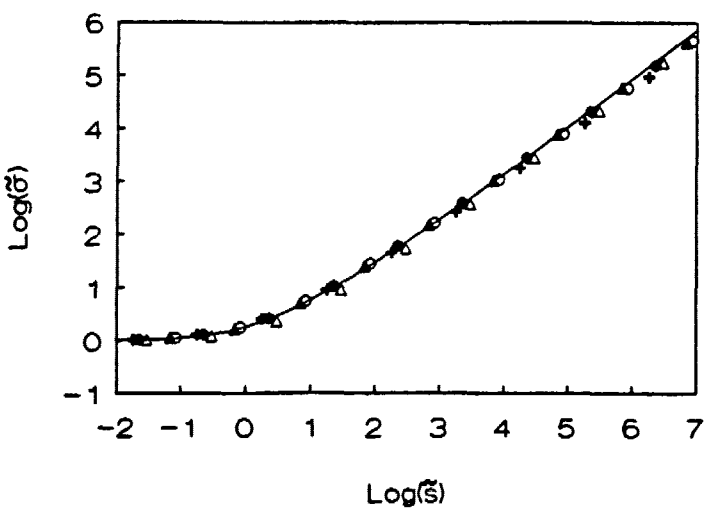

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Vejleder: Anders Madsen.

61/83 "FYSIKS IDEOLOGISKE FUNKTION, SOM ET EKSEMPEL PÅ EN NATURVIDENSKAB - HISTORISK SET".
Projektrapport af: Annette Post Nielsen.
Vejledere: Jens Høyrup, Jens Højgaard Jensen og Jørgen Vogelius.

62/83 "MATEMATISKE MODELLER" - Litteratur på Roskilde Universitetsbibliotek.
En biografi 2. rev. udgave.
Af: Else Høyrup.

63/83 "GREATING ENERGY FUTURES:A SHORT GUIDE TO ENERGY PLANNING".
ENERGY SERIES No. 8.
Af: David Crossley og Bent Sørensen.

64/83 "VON MATEMATIK UND KRIEG".
Af: Berhelm Booss og Jens Høyrup.

65/83 "ANVENDT MATEMATIK - TEORI ELLER PRAKSIS".
Projektrapport af: Per Hedegård Andersen, Kirsten Habekost, Carsten Holst-Jensen, Annelise von Moos, Else Marie Pedersen og Erling Møller Pedersen.
Vejledere: Bernhelm Booss og Klaus Grünbaum.

66/83 "MATEMATISKE MODELLER FOR PERIODISK SELEKTION I ESCHERICHIA COLI".
Projektrapport af: Hanne Lisbet Andersen, Ole Richard Jensen og Klavs Frisdahl.
Vejledere: Jørgen Larsen og Anders Hede Madsen.

67/83 "ELEPSOIDE METODEN - EN NY METODE TIL LINEÆR PROGRAMMERING?"
Projektrapport af: Lone Biilmann og Lars Boye.
Vejleder: Mogens Brun Heefelt.

68/83 "STOKASTISKE MODELLER I POPULATIONSGENETIK"
- til kritikken af teoriladede modeller.
Projektrapport af: Lise Odgård Gade, Susanne Hansen, Michael Hviid og Frank Mølgård Olsen.
Vejleder: Jørgen Larsen.

69/83 "ELEVFORUDSÆTNINGER I FYSIK"
- en test i 1.g med kommentarer.
Af: Albert C. Paulsen.

70/83 "INDLÆRINGS - OG FORMIDLINGSPROBLEMER I MATEMATIK PÅ VOKSENUNDERVISNINGSNIVEAU".
Projektrapport af: Hanne Lisbet Andersen, Torben J. Andreasen, Svend Åge Houmann, Helle Glerup Jensen, Keld Fl. Nielsen, Lene Vagn Rasmussen.
Vejleder: Klaus Grünbaum og Anders Hede Madsen.

71/83 "PIGER OG FYSIK"
- et problem og en udfordring for skolen?
Af: Karin Beyer, Sussanne Blegaa, Birthe Olsen, Jette Reich og Mette Vedelsby.

72/83 "VERDEN IFØLGE PEIRCE" - to metafysiske essays, om og af C.S Peirce.
Af: Peder Voetmann Christiansen.

73/83 ""EN ENERGIANALYSE AF LANDBRUG"
- økologisk contra traditionelt.
ENERGY SERIES NO. 9
Specialeopgave i fysik af: Bent Hove Jensen.
Vejleder: Bent Sørensen.

74/84 "MINIATURISERING AF MIKROELEKTRONIK" - om videnskabeliggjort teknologi og nytten af at lære fysik.
Projektrapport af: Bodil Harder og Linda Szkotak Jensen.
Vejledere: Jens Højgaard Jensen og Bent C. Jørgensen.

75/84 "MATEMATIKUNDERVISNINGEN I FREMTIDENS GYMNASIUM"
- Case: Lineær programmering.
Projektrapport af: Morten Blomhøj, Klavs Frisdahl og Frank Mølgaard Olsen.
Vejledere: Mogens Brun Heefelt og Jens Bjørneboe.

76/84 "KERNEKRAFT I DANMARK?" - Et høringssvar indkaldt af miljøministeriet, med kritik af miljøstyrelsens rapporter af 15. marts 1984.
ENERGY SERIES No. 10
Af: Niels Boye Olsen og Bent Sørensen.

77/84 "POLITISKE INDEKS - FUP ELLER FAKTA?"
Opinionsundersøgelser belyst ved statistiske modeller.
Projektrapport af: Svend Åge Houmann, Keld Nielsen og Susanne Stender.
Vejledere: Jørgen Larsen og Jens Bjørneboe.

78/84 "JÆVNSTRØMSLEDNINGSEVNE OG GITTERSTRUKTUT I AMORFT GERMANIUM".
Specialrapport af: Hans Hedal, Frank C. Ludvigsen og Finn C. Physant.
Vejleder: Niels Boye Olsen.

79/84 "MATEMATIK OG ALMENDANNELSE".
Projektrapport af: Henrik Coster, Mikael Wennerberg Johansen, Povl Kattler, Birgitte Lydholm og Morten Overgaard Nielsen.
Vejleder: Bernhelm Booss.

80/84 "KURSUSMATERIALE TIL MATEMATIK B".
Af: Mogens Brun Heefelt.

81/84 "FREKVENSAFHÆNGIG LEDNINGSEVNE I AMORFT GERMANIUM".
Specialerapport af: Jørgen Wind Petersen og Jan Christensen.
Vejleder: Niels Boye Olsen.

82/84 "MATEMATIK - OG FYSIKUNDERVISNINGEN I DET AUTOMATISEREDE SAMFUND".
Rapport fra et seminar afholdt i Hvidovre 25-27 april 1983.
Red.: Jens Højgaard Jensen, Bent C. Jørgensen og Mogens Niss.

83/84 "ON THE QUANTIFICATION OF SECURITY":
PEACE RESEARCH SERIES NO. 1
Af: Bent Sørensen
nr. 83 er p.t. udgået

84/84 "NOGLE ARTIKLER OM MATEMATIK, FYSIK OG ALMENDANNELSE".
Af: Jens Højgaard Jensen, Mogens Niss m. fl.

85/84 "CENTRIFUGALREGULATORER OG MATEMATIK".
Specialerapport af: Per Hedegård Andersen, Carsten Holst-Jensen, Else Marie Pedersen og Erling Møller Pedersen.
Vejleder: Stig Andur Pedersen.

86/84 "SECURITY IMPLICATIONS OF ALTERNATIVE DEFENSE OPTIONS FOR WESTERN EUROPE".
PEACE RESEARCH SERIES NO. 2
Af: Bent Sørensen.

87/84 "A SIMPLE MODEL OF AC HOPPING CONDUCTIVITY IN DISORDERED SOLIDS".
Af: Jeppe C. Dyre.

88/84 "RISE, FALL AND RESURRECTION OF INFINITESIMALS".
Af: Detlef Laugwitz.

89/84 "FJERNVARMEOPTIMERING".
Af: Bjarne Lillethorup og Jacob Mørch Pedersen.

90/84 "ENERGI I 1.G - EN TEORI FOR TILRETTELÆGGELSE".
Af: Albert Chr. Paulsen.

91/85 "KVANTETEORI FOR GYMNASIET".
1. Lærervejledning
Projektrapport af: Biger Lundgren, Henning Sten Hansen og John Johansson.
Vejleder: Torsten Meyer.

92/85 "KVANTETEORI FOR GYMNASIET".
2. Materiale
Projektrapport af: Biger Lundgren, Henning Sten Hansen og John Johansson.
Vejleder: Torsten Meyer.

93/85 "THE SEMIOTICS OF QUANTUM - NON - LOCALITY".
Af: Peder Voetmann Christiansen.

94/85 "TREENIGHEDEN BOURBAKI - generalen, matematikeren og ånden".
Projektrapport af: Morten Blomhøj, Klavs Frisdahl og Frank M. Olsen.
Vejleder: Mogens Niss.

95/85 "AN ALTERNATIV DEFENSE PLAN FOR WESTERN EUROPE".
PEACE RESEARCH SERIES NO. 3
Af: Bent Sørensen

96/85 "ASPEKTER VED KRAFTVARMEFORSYNING".
Af: Bjarne Lilletorup.
Vejleder: Bent Sørensen.

97/85 "ON THE PHYSICS OF A.C. HOPPING CONDUCTIVITY".
Af: Jeppe C. Dyre.

98/85 "VALGMULIGHEDER I INFORMATIONSALDEREN".
Af: Bent Sørensen.

99/85 "Der er langt fra Q til R".
Projektrapport af: Niels Jørgensen og Mikael Klintorp.
Vejleder: Stig Andur Pedersen.

100/85 "TALSYSTEMETS OPBYGNING".
Af: Mogens Niss.

101/85 "EXTENDED MOMENTUM THEORY FOR WINDMILLS IN PERTURBATIVE FORM".
Af: Ganesh Sengupta.

102/85 OPSTILLING OG ANALYSE AF MATEMATISKE MODELLER, BELYST VED MODELLER OVER KØERS FODEROPTAGELSE OG - OMSÆTNING".
Projektrapport af: Lis Eilertzen, Kirsten Habekost, Lill Røn og Susanne Stender.
Vejleder: Klaus Grünbaum.

103/85 "ØDSLE KOLDKRIGERE OG VIDENSKABENS LYSE IDEER".
Projektrapport af: Niels Ole Dam og Kurt Jensen.
Vejleder: Bent Sørensen.

104/85 "ANALOGREGNEMASKINEN OG LORENZLIGNINGER".
Af: Jens Jæger.

105/85 "THE FREQUENCY DEPENDENCE OF THE SPECIFIC HEAT AF THE GLASS REANSITION".
Af: Tage Christensen.

"A SIMPLE MODEL AF AC HOPPING CONDUCTIVITY".
Af: Jeppe C. Dyre.
Contributions to the Third International Conference on the Structure of Non - Crystalline Materials held in Grenoble July 1985.

106/85 "QUANTUM THEORY OF EXTENDED PARTICLES".
Af: Bent Sørensen.

107/85 "EN MYG GØR INGEN EPIDEMI".
- flodblindhed som eksempel på matematisk modellering af et epidemiologisk problem.
Projektrapport af: Per Hedegård Andersen, Lars Boye, CarstenHolst Jensen, Else Marie Pedersen og Erling Møller Pedersen.
Vejleder: Jesper Larsen.

108/85 "APPLICATIONS AND MODELLING IN THE MATEMATICS CURRICULUM" - state and trends -
Af: Mogens Niss.

109/85 "COX I STUDIETIDEN" - Cox's regressionsmodel anvendt på studenteroplysninger fra RUC.
Projektrapport af: Mikael Wennerberg Johansen, Poul Katler og Torben J. Andreasen.
Vejleder: Jørgen Larsen.

110/85 "PLANNING FOR SECURITY".
Af: Bent Sørensen

111/85 JORDEN RUNDT PÅ FLADE KORT".
Projektrapport af: Birgit Andresen, Beatriz Quinones og Jimmy Staal.
Vejleder: Mogens Niss.

112/85 "VIDENSKABELIGGØRELSE AF DANSK TEKNOLOGISK INNOVATION FREM TIL 1950 - BELYST VED EKSEMPLER".
Projektrapport af: Erik Odgaard Gade, Hans Hedal, Frank C. Ludvigsen, Annette Post Nielsen og Finn Physant.
Vejleder: Claus Bryld og Bent C. Jørgensen.

113/85 "DESUSPENSION OF SPLITTING ELLIPTIC SYMBOLS II".
Af: Bernhelm Booss og Krzysztof Wojciechowski.

114/85 "ANVENDELSE AF GRAFISKE METODER TIL ANALYSE AF KONTIGENSTABELLER".
Projektrapport af: Lone Biilmann, Ole R. Jensen og Anne-Lise von Moos.
Vejleder: Jørgen Larsen.

115/85 "MATEMATIKKENS UDVIKLING OP TIL RENÆSSANCEN".
Af: Mogens Niss.

116/85 "A PHENOMENOLOGICAL MODEL FOR THE MEYER-NELDEL RULE".
Af: Jeppe C. Dyre.

117/85 "KRAFT & FJERNVARMEOPTIMERING"
Af: Jacob Mørch Pedersen.
Vejleder: Bent Sørensen

118/85 "TILFÆLDIGHEDEN OG NØDVENDIGHEDEN IFØLGE PEIRCE OG FYSIKKEN".
Af: Peder Voetmann Christiansen

119/86 "DET ER GANSKE VIST - - EUKLIDS FEMTE POSTULAT KUNNE NOK SKABE RØRE I ANDEDAMMEN".
Af: Iben Maj Christiansen
Vejleder: Mogens Niss.

120/86 "ET ANTAL STATISTISKE STANDARDMODELLER".
Af: Jørgen Larsen

121/86 "SIMULATION I KONTINUERT TID".
Af: Peder Voetmann Christiansen.

122/86 "ON THE MECHANISM OF GLASS IONIC CONDUCTIVITY".
Af: Jeppe C. Dyre.

123/86 "GYMNASIEFYSIKKEN OG DEN STORE VERDEN".
Fysiklærerforeningen, IMFUFA, RUC.

124/86 "OPGAVESAMLING I MATEMATIK".
Samtlige opgaver stillet i tiden 1974-jan. 1986.

125/86 "UVBY,β - systemet - en effektiv fotometrisk spektralklassifikation af B-,A- og F-stjerner".
Projektrapport af: Birger Lundgren.

126/86 "OM UDVIKLINGEN AF DEN SPECIELLE RELATIVITETSTEORI".
Projektrapport af: Lise Odgaard & Linda Szkotak Jensen
Vejledere: Karin Beyer & Stig Andur Pedersen.

127/86 "GALOIS' BIDRAG TIL UDVIKLINGEN AF DEN ABSTRAKTE ALGEBRA".
Projektrapport af: Pernille Sand, Heine Larsen & Lars Frandsen.
Vejleder: Mogens Niss.

128/86 "SMÅKRYB" - om ikke-standard analyse.
Projektrapport af: Niels Jørgensen & Mikael Klintorp.
Vejleder: Jeppe Dyre.

129/86 "PHYSICS IN SOCIETY"
Lecture Notes 1983 (1986)
Af: Bent Sørensen

130/86 "Studies in Wind Power"
Af: Bent Sørensen

131/86 "FYSIK OG SAMFUND" - Et integreret fysik/historieprojekt om naturanskuelsens historiske udvikling og dens samfundsmæssige betingethed.
Projektrapport af: Jakob Heckscher, Søren Brønd, Andy Wierød.
Vejledere: Jens Høyrup, Jørgen Vogelius, Jens Højgaard Jensen.

132/86 "FYSIK OG DANNELSE"
Projektrapport af: Søren Brønd, Andy Wierød.
Vejledere: Karin Beyer, Jørgen Vogelius.

133/86 "CHERNOBYL ACCIDENT: ASSESSING THE DATA.
ENERGY SERIES NO. 15.
AF: Bent Sørensen.

134/87 "THE D.C. AND THE A.C. ELECTRICAL TRANSPORT IN AsSeTe SYSTEM"
Authors: M.B.El-Den, N.B.Olsen, Ib Høst Pedersen, Petr Viščor

135/87 "INTUITIONISTISK MATEMATIKS METODER OG ERKENDELSESTEORETISKE FORUDSÆTNINGER"
MASTEMATIKSPECIALE: Claus Larsen
Vejledere: Anton Jensen og Stig Andur Pedersen

136/87 "Mystisk og naturlig filosofi: En skitse af kristendommens første og andet møde med græsk filosofi"
Projektrapport af Frank Colding Ludvigsen
Vejledere: Historie: Ib Thiersen
Fysik: Jens Højgaard Jensen

137/87 "HOPMODELLER FOR ELEKTRISK LEDNING I UORDNEDE FASTE STOFFER" - Resume af licentiatafhandling
Af: Jeppe Dyre
Vejledere: Niels Boye Olsen og Peder Voetmann Christiansen.

138/87 "JOSEPHSON EFFECT AND CIRCLE MAP."

Paper presented at The International Workshop on Teaching Nonlinear Phenomena at Universities and Schools, "Chaos in Education". Balaton, Hungary, 26 April-2 May 1987.

By: Peder Voetmann Christiansen

139/87 "Machbarkeit nichtbeherrschbarer Technik durch Fortschritte in der Erkennbarkeit der Natur"

Af: Bernhelm Booss-Bavnbek
Martin Bohle-Carbonell

140/87 "ON THE TOPOLOGY OF SPACES OF HOLOMORPHIC MAPS"

By: Jens Gravesen

141/87 "RADIOMETERS UDVIKLING AF BLODGASAPPARATUR - ET TEKNOLOGIHISTORISK PROJEKT"

Projektrapport af Finn C. Physant

Vejleder: Ib Thiersen

142/87 "The Calderón Projektor for Operators With Splitting Elliptic Symbols"

by: Bernhelm Booss-Bavnbek og
Krzysztof P. Wojciechowski

143/87 "Kursusmateriale til Matematik på NAT-BAS"

af: Mogens Brun Heefelt

144/87 "Context and Non-Locality - A Peircean Approach

Paper presented at the Symposium on the Foundations of Modern Physics The Copenhagen Interpretation 60 Years after the Como Lecture. Joensuu, Finland, 6 - 8 august 1987.

By: Peder Voetmann Christiansen

145/87 "AIMS AND SCOPE OF APPLICATIONS AND MODELLING IN MATHEMATICS CURRICULA"

Manuscript of a plenary lecture delivered at ICMTA 3, Kassel, FRG 8.-11.9.1987

By: Mogens Niss

146/87 "BESTEMMELSE AF BULKRESISTIVITETEN I SILICIUM"

- en ny frekvensbaseret målemetode.

Fysikspeciale af Jan Vedde

Vejledere: Niels Boye Olsen & Petr Viščor

147/87 "Rapport om BIS på NAT-BAS"

redigeret af: Mogens Brun Heefelt

148/87 "Naturvidenskabsundervisning med Samfundsperspektiv"

af: Peter Colding-Jørgensen DLH
Albert Chr. Paulsen

149/87 "In-Situ Measurements of the density of amorphous germanium prepared in ultra high vacuum"

by: Petr Viščor

150/87 "Structure and the Existence of the first sharp diffraction peak in amorphous germanium prepared in UHV and measured in-situ"

by: Petr Viščor

151/87 "DYNAMISK PROGRAMMERING"

Matematikprojekt af:
Birgit Andresen, Keld Nielsen og Jimmy Staal

Vejleder: Mogens Niss

152/87 "PSEUDO-DIFFERENTIAL PROJECTIONS AND THE TOPOLOGY OF CERTAIN SPACES OF ELLIPTIC BOUNDARY VALUE PROBLEMS"

by: Bernhelm Booss-Bavnbek
Krzysztof P. Wojciechowski

153/88 "HALVLEDERTEKNOLOGIENS UDVIKLING MELLEM MILITÆRE OG CIVILE KRÆFTER"

Et eksempel på humanistisk teknologihistorie
Historiespeciale

Af: Hans Hedal

Vejleder: Ib Thiersen

154/88 "MASTER EQUATION APPROACH TO VISCOUS LIQUIDS AND THE GLASS TRANSITION"

By: Jeppe Dyre

155/88 "A NOTE ON THE ACTION OF THE POISSON SOLUTION OPERATOR TO THE DIRICHLET PROBLEM FOR A FORMALLY SELFADJOINT DIFFERENTIAL OPERATOR"

by: Michael Pedersen

156/88 "THE RANDOM FREE ENERGY BARRIER MODEL FOR AC CONDUCTION IN DISORDERED SOLIDS"

by: Jeppe C. Dyre

157/88 " STABILIZATION OF PARTIAL DIFFERENTIAL EQUATIONS BY FINITE DIMENSIONAL BOUNDARY FEEDBACK CONTROL: A pseudo-differential approach."

by: Michael Pedersen

158/88 "UNIFIED FORMALISM FOR EXCESS CURRENT NOISE IN RANDOM WALK MODELS"

by: Jeppe Dyre

159/88 "STUDIES IN SOLAR ENERGY"

by: Bent Sørensen

160/88 "LOOP GROUPS AND INSTANTONS IN DIMENSION TWO"

by: Jens Gravesen

161/88 "PSEUDO-DIFFERENTIAL PERTURBATIONS AND STABILIZATION OF DISTRIBUTED PARAMETER SYSTEMS:

Dirichlet feedback control problems"

by: Michael Pedersen

162/88 "PIGER & FYSIK - OG MEGET MERE"

AF: Karin Beyer, Sussanne Blegaa, Birthe Olsen,
Jette Reich , Mette Vedelsby

163/88 "EN MATEMATISK MODEL TIL BESTEMMELSE AF PERMEABILITETEN FOR BLOD-NETHINDE-BARRIEREN"

Af: Finn Langberg, Michael Jarden, Lars Frellesen

Vejleder: Jesper Larsen

164/88 "Vurdering af matematisk teknologi
Technology Assessment
Technikfolgenabschätzung"

Af: Bernhelm Booss-Bavnbek, Glen Pate med
Martin Bohle-Carbonell og Jens Højgaard Jensen

165/88 "COMPLEX STRUCTURES IN THE NASH-MOSER CATEGORY"

by: Jens Gravesen

166/88 "Grundbegreber i Sandsynligheds-regningen"

Af: Jørgen Larsen

167a/88 "BASISSTATISTIK 1. Diskrete modeller"

Af: Jørgen Larsen

167b/88 "BASISSTATISTIK 2. Kontinuerte modeller"

Af: Jørgen Larsen

168/88 "OVERFLADEN AF PLANETEN MARS"
Laboratorie-simulering og MARS-analoger undersøgt ved Mössbauerspektroskopi.

Fysikspeciale af:

Birger Lundgren

Vejleder: Jens Martin Knudsen
Fys.Lab./HCØ

169/88 "CHARLES S. PEIRCE: MURSTEN OG MØRTEL TIL EN METAFYSIK."

Fem artikler fra tidsskriftet "The Monist" 1891-93.

Introduktion og oversættelse:

Peder Voetmann Christiansen

170/88 "OPGAVESAMLING I MATEMATIK"

Samtlige opgaver stillet i tiden 1974 - juni 1988

171/88 "The Dirac Equation with Light-Cone Data"

af: Johnny Tom Ottesen

172/88 "FYSIK OG VIRKELIGHED"

Kvantemekanikkens grundlagsproblem i gymnasiet.

Fysikprojekt af:

Erik Lund og Kurt Jensen

Vejledere: Albert Chr. Paulsen og Peder Voetmann Christiansen

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173/89 "NUMERISKE ALGORITMER"

af: Mogens Brun Heefelt

174/89 " GRAFISK FREMSTILLING AF FRAKTALER OG KAOS"

af: Peder Voetmann Christiansen

175/89 " AN ELEMENTARY ANALYSIS OF THE TIME DEPENDENT SPECTRUM OF THE NON-STATONARY SOLUTION TO THE OPERATOR RICCATI EQUATION

af: Michael Pedersen

176/89 " A MAXIUM ENTROPY ANSATZ FOR NONLINEAR RESPONSE THEORY"

af : Jeppe Dyre

177/89 "HVAD SKAL ADAM STÅ MODEL TIL"

af: Morten Andersen, Ulla Engström, Thomas Gravesen, Nanna Lund, Pia Madsen, Dina Rawat, Peter Torstensen

Vejleder: Mogens Brun Heefelt

178/89 "BIOSYNTESEN AF PENICILLIN - en matematisk model"

af: Ulla Eghave Rasmussen, Hans Oxvang Mortensen, Michael Jarden

vejleder i matematik: Jesper Larsen
biologi: Erling Lauridsen

179a/89 "LÆRERVEJLEDNING M.M. til et eksperimentelt forløb om kaos"

af: Andy Wierød, Søren Brønd og Jimmy Staal

Vejledere: Peder Voetmann Christiansen
Karin Beyer

179b/89 "ELEVHÆFTE: Noter til et eksperimentelt kursus om kaos"

af: Andy Wierød, Søren Brønd og Jimmy Staal

Vejledere: Peder Voetmann Christiansen
Karin Beyer

180/89 "KAOS I FYSISKE SYSTEMER eksemplificeret ved torsions- og dobbeltpendul".

af: Andy Wierød, Søren Brønd og Jimmy Staal
Vejleder: Peder Voetmann Christiansen

181/89 "A ZERO-PARAMETER CONSTITUTIVE RELATION FOR PURE SHEAR VISCOELASTICITY"

by: Jeppe Dyre

183/89 "MATEMATICAL PROBLEM SOLVING, MODELLING. APPLICATIONS AND LINKS TO OTHER SUBJECTS - State. trends and issues in mathematics instruction

by: WERNER BLUM, Kassel (FRG) og
MOGENS NISS, Roskilde (Denmark)

184/89 "En metode til bestemmelse af den frekvensafhængige varmefylde af en underafkølet væske ved glasovergangen"

af: Tage Emil Christensen

185/90 "EN NÆSTEN PERIODISK HISTORIE"

Et matematisk projekt

af: Steen Grode og Thomas Jessen

Vejleder: Jacob Jacobsen

186/90 "RITUAL OG RATIONALITET i videnskabers udvikling"

redigeret af Arne Jakobsen og Stig Andur Pedersen

187/90 "RSA - et kryptografisk system"

af: Annemette Sofie Olufsen, Lars Frellesen
og Ole Møller Nielsen

Vejledere: Michael Pedersen og Finn Munk

188/90 "FERMICONDENSATION - AN ALMOST IDEAL GLASS TRANSITION"

by: Jeppe Dyre

189/90 "DATAMATER I MATEMATIKUNDERVISNINGEN PÅ GYMNASIET OG HØJERE LÆREANSTALTER

af: Finn Langberg

190/90 "FIVE REQUIREMENTS FOR AN APPROXIMATE NONLINEAR RESPONSE THEORY"

by: Jeppe Dyre

191/90 "MOORE COHOMOLOGY, PRINCIPAL BUNDLES AND ACTIONS OF GROUPS ON C*-ALGEBRAS"

by: Iain Raeburn and Dana P. Williams

192/90 "Age-dependent host mortality in the dynamics of endemic infectious diseases and SIR-models of the epidemiology and natural selection of co-circulating influenza virus with partial cross-immunity"

by: Viggo Andreasen

193/90 "Causal and Diagnostic Reasoning"

by: Stig Andur Pedersen

194a/90 "DETERMINISTISK KAOS"

Projektrapport af : Frank Olsen

194b/90 "DETERMINISTISK KAOS"
Kørselsrapport

Projektrapport af: Frank Olsen

195/90 "STADIER PÅ PARADIGMETS VEJ"
Et projekt om den videnskabelige udvikling der førte til dannelse af kvantemekanikken.

Projektrapport for 1. modul på fysikuddannelsen, skrevet af:

Anja Boisen, Thomas Hougård, Anders Gorm Larsen, Nicolai Ryge.

Vejleder: Peder Voetmann Christiansen

196/90 "ER KAOS NØDVENDIGT?"

- en projektrapport om kaos' paradigmatiske status i fysikken.

af: Johannes K. Nielsen, Jimmy Staal og Peter Bøggild

Vejleder: Peder Voetmann Christiansen

197/90 "Kontrafaktiske konditionaler i HOL

af: Jesper Voetmann, Hans Oxvang Mortensen og Aleksander Høst-Madsen

Vejleder: Stig Andur Pedersen

198/90 "Metal-Isolator-Metal systemer"

Speciale

af: Frank Olsen

199/90 "SPREDT FÆGTNING" Artikelsamling

af: Jens Højgaard Jensen

200/90 "LINEÆR ALGEBRA OG ANALYSE"

Noter til den naturvidenskabelige basisuddannelse.

af: Mogens Niss

201/90 "Undersøgelse af atomare korrelationer i amorfe stoffer ved røntgendiffraktion"

af: Karen Birkelund og Klaus Dahl Jensen

Vejledere: Petr Viščor, Ole Bakander

202/90 "TEGN OG KVANTER"
Foredrag og artikler, 1971-90.

af: Peder Voetmann Christiansen

203/90 "OPGAVESAMLING I MATEMATIK" 1974-1990

afløser tekst 170/88

204/91 "ERKENDELSE OG KVANTEMEKANIK"

et Breddemodul Fysik Projekt

af: Thomas Jessen

Vejleder: Petr Viščor

205/91 "PEIRCE'S LOGIC OF VAGUENESS"

by: Claudine Engel-Tiercelin
Department of Philosophy
Université de Paris-1
(Panthéon-Sorbonne)

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Eksperimentelt Fysikspeciale

af: Jeanne Linda Mortensen

og Annette Post Nielsen

Vejleder: Petr Viščor

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