THREE-YEAR GRANT PROPOSAL
EXPERIMENTAL AND THEORETICAL RESEARCH IN
APPLIED PLASMA PHYSICS

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PLASMA FUSION CENTER
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MA  02139

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MASTER
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## GRANT PROPOSAL
### EXPERIMENTAL AND THEORETICAL RESEARCH
#### IN APPLIED PLASMA PHYSICS

### TASK ACTIVITIES

<table>
<thead>
<tr>
<th>Task #</th>
<th>Task Title</th>
<th>Principal and Co-Principal Investigators</th>
</tr>
</thead>
<tbody>
<tr>
<td>APP-01</td>
<td>Fusion Theory and Computations</td>
<td>Dieter Sigmar, Abraham Bers, Jeffrey Freidberg, Jay Kesner, Abhay Ram, Jesus Ramos</td>
</tr>
<tr>
<td>APP-02</td>
<td>Theory of Thermonuclear Plasmas</td>
<td>Bruno Coppi</td>
</tr>
<tr>
<td>APP-03</td>
<td>User Service Center</td>
<td>Martin Greenwald</td>
</tr>
<tr>
<td>APP-04</td>
<td>Versator Tokamak Research</td>
<td>Miklos Porkolab, Ronald Parker</td>
</tr>
<tr>
<td>APP-05</td>
<td>Alcator C-MOD Diagnostic Development</td>
<td>Ian Hutchinson, James Irby, Brian LaBombard</td>
</tr>
<tr>
<td>APP-06A</td>
<td>High Poloidal Beta Studies on PBX-M</td>
<td>Stanley Luckhardt, Jay Kesner</td>
</tr>
<tr>
<td>APP-06B</td>
<td>Fast Electron Cyclotron Emission Diagnostic</td>
<td>Paul Woskov, Stanley Luckhardt, Daniel Cohn</td>
</tr>
<tr>
<td>APP-07</td>
<td>X-Ray Imaging Diagnostic</td>
<td>Richard Petraso</td>
</tr>
<tr>
<td>APP-08</td>
<td>Gamma Ray Imaging Diagnostic</td>
<td>Richard Petraso</td>
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<tr>
<td>APP-09</td>
<td>Millimeter/Submillimeter-Wave Fusion Ion Diagnostics</td>
<td>Paul Woskov, Daniel Cohn</td>
</tr>
<tr>
<td>APP-10</td>
<td>Small-Scale Turbulence and Nonlinear Dynamics in Plasmas</td>
<td>Paul Linsay</td>
</tr>
<tr>
<td>APP-11</td>
<td>TFTR High Beta Collaboration</td>
<td>Jay Kesner</td>
</tr>
<tr>
<td>APP-12</td>
<td>Plasma Turbulence and Transport</td>
<td>Dieter Sigmar, Tom Dupree</td>
</tr>
<tr>
<td>APP-13</td>
<td>Phase Contrast Interferometer Diagnostic for DIII-D</td>
<td>Miklos Porkolab</td>
</tr>
</tbody>
</table>
toroidal Alfvén modes destabilized by alphas, zero and 1-D calculations of burn control via auxiliary heating (by J. P. Freidberg et al).

(iv) Effects of low plasma current, high $\beta_p$, tokamak operation on stability (second stability) and transport (high local shear stabilization of $\eta_i$ modes) (by J. Kesner et al).

(v) Theory of the tokamak beta limit: fundamentally new analysis and extension of the Troyon limit and its dependence on the total $q$ profile including the central $q$ value, and the regime of high $q$ values for all radii. Consequences for novel access routes to second stability (by J. J. Ramos et al).

(i) Subtask Impurity and Alpha Transport

Principal Investigator: Dieter J. Sigmar

Subtask Summary

Extension of standard neoclassical theory to the nonlinear regime and ensuing bifurcation of transport equilibria; inclusion of impurities in the $\eta_i$ mode; fast $\alpha$ neoclassical and anomalous transport due to MHD-like modes

II. Proposed Research

A. Background and Current Research

Nonlinear neoclassical description of impurity transport (C. T. Hsu, D. J. Sigmar)

Poloidal equilibria (encompassing the poloidal flows and poloidal density and temperature variations) of the tokamak plasma under the influence of
impurities have been studied. (The theory applies for all plasmas with $\frac{n_e Z^2}{n_i} > \sqrt{m_e/m_i}$, or $Z_{eff} \geq 1.1$.) As a consequence of the nonlinear coupling between poloidal flow and poloidal density variations, bifurcation of poloidal equilibria are found [1, 12] which can alter the transport behavior of tokamak plasmas within the transit (or collisional) time scale, in the outer region of the tokamak plasma. The nonlinearity comes from the strong up-down variation of the impurity density [2a, 2b] in the flux surface

$$\frac{\tilde{n}_x(\theta)}{n_x} \sim O \left( \frac{r}{R} \right)$$

which is a consequence of the appropriate (but hitherto not seriously considered) “strong ordering” [1], $\Delta \equiv (\rho_{pi}/r_n) Z^2 \nu_{ii}/\omega_{ti} \sim 1$, where $\rho_{pi}$ is the poloidal main ion Larmor radius, $r_n$ the characteristic radial gradient scale length, $Z$ the impurity charge, $\nu_{ii}$ the ion-ion collision frequency and $\omega_{ti}$ the main ion transit frequency, and $\nu_{ii} \gtrsim \omega_{ti}$ describes the plateau-Pfirsch-Schlüter regime near the edge. The bifurcated solutions (see Fig. next page) for the poloidal flows and ensuing radial particle and energy transport have features compatible with the transition to the H-mode and may be the classical foundation for the L to H transition upon which the anomalous edge transport changes are predicated.

**Extended impurity transport theory (including strong poloidal asymme-

The observation of central impurity peaking in enhanced confinement regimes is of great interest to the achievement of fusion burn. Even simple forms of neoclassical theory predict such peaking but typically, light impurities (e.g. carbon) are in the BP regime and the metallic impurities are in the PS regime including various transition effects between collisionality regimes. This
Appearance of multiple roots of poloidal impurity flow $U_I$

obtained from $\langle B \cdot \nabla \cdot \Pi_I \rangle = \langle B \cdot R_{I-i} \rangle$

$A_d a_\Delta = 4.3$

$A_d \sim$ inverse radial gradient scale (dimensionless)

$a_\Delta \sim \Delta$, strong ordering parameter

necessitates using the full \( \nu_\ast \)-dependent prescriptions for the impurity fluxes, and inter-impurity friction. So far, the "standard theory" [c.f. Ref. 17] has ignored the observed strong [i.e. \( O(\epsilon) \)] poloidal up-down asymmetries of the impurity density in the flux surface. Within this approximation, the theory yields good agreement with experimental profiles in some cases but, in other cases, the theoretical ratio \( \frac{V}{D} \) of inward convection versus diffusion is too small and thus the profile too broad.

Consequently, before postulating anomalous convection but neoclassical-like diffusion for the same impurity we systematically retain the \( \bar{n}_z(r, \theta)/n_z \sim O(\epsilon) \) nonlinearity in the neoclassical transport formalism [1] and by evaluating specific Alcator C and TEXT discharges analyze the predicted effect of this strong poloidal asymmetry (and concomitant poloidal electric field produced convection) on the observed "excess" carbon peaking.

**Neoclassical losses of fusion-produced energetic particles** (D. T. Hsu, P. Catto, D. J. Sigmar)

The work extends previous studies by Nocentini et al [3] and by Catto [4] in which either the effects of pitch angle scattering (PA) or slowing down (SD) drag were mostly omitted. In our study [5] we included both collisional effects rigorously as well as the effects of finite aspect ratio, by adopting a novel eigenfunction technique. Significant modification from the previous results were found, due to the exact treatment of the balance between PA and SD collisional forces, in the relevant parameter regimes. The consequences of our rigorous results do not substantially change the conventional slowing down treatment of most \( \alpha \) particles from D-T burning tokamak plasmas. Alphas in the trapped circulating particle boundary layer are affected, however. For advanced fuels such as D-\(^3\)He where \( v_o/v_{crit} \) is much larger, the fusion products are less well
Principal Investigator

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Sr. Research Scientist on Plasma Turbulence Topic

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I. Task Summary

This task contains a collection of proposed works on fundamental and applied theory of turbulence in magnetized plasmas and ensuing anomalous transport. The topics encompass (i) formation, stability and dynamics of coherent structures in plasma turbulence; (ii) nonlinear theory of alpha driven ballooning modes; (iii) influence of radial electric field on turbulent fluctuations and relation to enhanced confinement regimes; and (iv) effects of poloidal impurity variations on the $\eta_i$ turbulence and particle transport.
prediction would be possible by choosing a specific plasma turbulence regime. The relevant experimental verification methods would be developed to conform with theoretical predictions.

4. **G. S. Lee (with D. J. Sigmar), “Effects of Poloidal Impurity Concentration on the Theory of Ion-Temperature Gradient Driven Turbulence and Particle Transport in Tokamaks.”**

   In our previous work [13] a simple cold impurity model was used to investigate the effects of impurity ion concentration on saturated ion temperature gradient driven turbulence. We propose to incorporate anomalous impurity ion dynamics, thereby extending the recent neoclassical work by K. Wenzel and D. J. Sigmar [14], to understand the anomalous particle transport and impurity transport with impurity puffing, as well as impurity pellet injection experiments performed in various tokamaks. Observed experimental evidence of poloidally varying impurity equilibrium profiles might play a significant role in determining low frequency turbulent transport. We will investigate the possible consequences of poloidal impurity density variations into the theory of the $\eta_i$ mode turbulence.

5. **G. S. Lee (with student/postdoc), “Induced Transport due to Ion-Temperature-Gradient Turbulence in the Low Collisionality Regime of a Tokamak Plasma.”**

   In our previous work on $\eta_i$ mode turbulence [13], we investigated the induced electron thermal diffusivity $\chi_e$, and the particle transport flux due to underlying ion temperature gradient driven turbulence in the high collisionality limit of the banana regime where $\omega, \bar{w}_{De} \ll \nu_{eff,e}$. However, the collisionality regime of the central plasma of high temperature tokamaks is shown to be characterized by much lower collisionality than assumed previously. We will extend
1965 ScD, Technical University of Vienna
1966-1970 Research Staff, Fusion Energy Division of Oak Ridge
      National Laboratory (ORNL)
1970-1974 Postdoctoral Fellow and Lecturer at MIT
1974-1978 Associate Professor, Nuclear Engineering Department, MIT
1978-1985 Head, Tokamak Theory Group, Fusion Energy Division of ORNL
1981-present a.o. Prof. of Theoretical Physics, Technical University of Vienna
1985-89 Adjunct Professor of Nuclear Engineering and Plasma Fusion
      Center, MIT
1989-present Senior Research Scientist and Head, Theory Group, at
      Plasma Fusion Center, MIT

B. Recent Publications

Invited Talks

D. J. Sigmar, “Impurity Transport Including Bifurcation of Poloidal Flow
and Transport Fluxes,” Joint Varenna-Lausanne International Workshop on

D. J. Sigmar, “Impurity Transport Theory: Central Peaking and Large
Up/Down Density Variations,” ASDEX Workshop, Ringberg, W. Germany,

D. J. Sigmar, “Alpha Physics Issues and Relation to $\alpha$ Diagnostics Needs
for CIT,” $\alpha$ Diagnostic Workshop, Germantown, December 1989.

D. J. Sigmar, “Physics Problems of Magnetic Confinement of Fusion Plas-
mas,” Physics Colloquium Univ. N.Y. at Stonybrook, Nov. 1988

D. J. Sigmar, “Alpha Particle Effects on Tokamak Energy Confinement


Foreign Travel Report

D. J. Sigmar and C. T. Hsu

Attending ASDEX Ringberg Seminar, September 18-22, 1989 near Munich, West Germany.
Purpose

- The annual Ringberg Seminar of the ASDEX Tokamak Experimental Group of Max Planck Institut für Plasmaphysik is primarily an internal affair, but every other year, a few selected foreign specialists are invited to attend. This year's topics focussed on classical and anomalous plasma transport and comparisons between experiment and theory.

Abstract

I The 4-1/2 day intensive workshop consisted of a well planned mixture of theoretical and experimental talks and related discussion sessions on (i) anomalous transport of the bulk plasma (fluctuation theory and experiment); (ii) neoclassical-like impurity transport in enhanced confinement regimes (theory and experiment); and (iii) the isotope dependence of the confinement time. Highlights included (in order of the conference schedule, see Appendix A) measurement of orthogonal conductivity in tokamaks and its relevance to H-mode (Weynadts), lectures on drift wave and \( \eta_k \)-mode theory (Bruce Scott), viscosity and toroidal momentum confinement on ASDEX (Kallenbach), central impurity peaking in ASDEX (Fussmann and Krieger), JET (Behringer) and DIIII-D (Lippman), the two talks by the travellers (D. J. Sigmar, C. T. Hsu) on impurity peaking, up/down asymmetry, co-/vs. counter-injection, toroidal rotation damping, and possible bifurcation of the transport equilibrium, all based on a new nonlinear collisional transport theory using the strong ordering; a new variational approach to impurity transport theory (Samain), studies of the isotope dependence of \( \tau_E \) in TEXTOR (Samm) and ASDEX (Wagner), MHD mode locking (Zohm) and energy transport with LH heating and current drive in ASDEX (Söldner).

There was a remarkable degree of interest by the experimentalists to learn and to understand predictions, capabilities and limitations of transport theory (both anomalous and impurity-neoclassical). One discussion session concerned resolution of different mixed regime transport coefficients in the impurity theories of Samain et al. on one hand and Hirshman-Sigmar on the other. Samain was basically willing to go with the transport
matrix results of Hirshman-Sigmar. Sigmar offered to revisit some of the numerical details in his review paper concerning the various numerical coefficients in the transport coefficients. The experimentalists are keenly interested to use the final outcome of this effort and any further developments in their transport modelling of impurity peaking experiments. Since ASDEX contains two copious impurities (carbon and copper) in mixed collisionality regimes, the existing theory of Hirshman et al. needs to be extended. Preliminary agreement was established for further collaboration between the ASDEX group and Sigmar-Hsu in the coming 9–12 months.

II After the close of the Ringberg seminar, D. J. Sigmar visited several of the US-European ITER team members to discuss the coordination of interests in the upcoming Kiev meeting on Alpha Particle Physics (October 23–26, 1989), sponsored by the IAEA and organized by Kolesnichenko (for the USSR) and Sigmar (for the US). The (mainly theoretical) conference is expected to yield results in a variety of ignited plasma topics applicable to ITER and CIT.

Brief Account of Individual Talks

1 Niedermeyer (ASDEX) described an experimentalist’s picture of turbulence. He pointed out that although the solution to the turbulence problem may not ever be found fully by theory, theory is useful in reducing the degrees of freedom in parameter space and thus could lead to better scaling laws. Experimentalists need to know the limitations of the theories rather than understanding the formalism in detail. They also need to know the mode signatures in order to identify the various types of instability which drive the turbulent transport.

2 Holzhauer (University of Stuttgart), Scott (ASDEX) and Waltz (GA) gave a series of lectures on the theory of turbulent transport. B. Scott (a young US theorist on a three year appointment at MPIPP) brought fresh enthusiasm to this difficult topic. The general descriptions and limitations of the various closure schemes (e.g. mixing length theory, DIA) used to deal with turbulent spectrum were given in an overview type of way. Also, the dynamics of nonlinear instabilities were given (such as how the energy cascades,
how the dissipation sinks stimulate the nonlinear wave evolution, etc.). Moreover, it was repeatedly emphasized that the characteristics of the instability in the linear regime are not adequate in nonlinear systems, even with the same driving mechanism. E.g. turbulence can exist even when the system is far below linear threshold! Scott is now preparing to do a direct numerical fluid simulation of drift wave turbulence including effects of $\eta_i$ and FLR effects. However, to include the effects of $\rho_i \Delta_\perp \sim 1$ which is relevant in this case, he needs to improve his fluid equations (cf. Hsu, Hazeltine and Morrison, Phys. Fluids 29, 1480 (1986)). Scott’s numerical algorithms are powerful and endeavor to resolve the various boundary layers of the drift radial eigenmode problem.

3 Samain (Cadarache) displayed a new look at (nonlinear) microtearing modes and their effect on anomalous transport and discussed the (hotly debated) problem of self-sustainment of the electron stochastic regions and island chains. Overall, Samain’s results seem to support the claims of Rebut-Lallia in this regard who derive anomalous electron transport from this type of mechanism.

4 Rudy, Krämer (ASDEX) have measured the edge density fluctuation for various discharges. In particular, they found a distinct decrease of fluctuation levels during the L-H transition. However, the fluctuations are measured outside the separatrix where flux surfaces are not closed and several sources provide perturbations through sputtering, charge exchange, etc. It is not yet clear whether these fluctuations are indeed causing the turbulent transport. A study of fluctuations inside the separatrix will be more desirable.

5 Stroth (ASDEX) reported the confinement properties of sawtooth-free discharges which have to be operated below a certain density limit. In general, these discharges have better confinement, but this requires (or results in) a more peaked density profile which then causes an increase in impurity line radiation. The concomitant central impurity accumulation leads to suppression of sawtoothing.

6 Kallenbach (ASDEX) reported observations of toroidal momentum confinement. He concluded that no neoclassical theories he knew about can explain the observed momentum transport. (However, a new neoclassical transport which includes nonlinear effects by Hsu and Sigmar, and was presented at this conference, has not been considered yet. It would be
strange to have neoclassical-like particle and ion heat transport but anomalous momentum transport.)

7 Grassie (ASDEX) showed theoretical results on the stabilization of ballooning modes by toroidal shearflow. He acknowledged the (by now well known) problems of ideal MHD theory to accommodate the effect of $\partial v_r / \partial r \neq 0$ but showed a calculation at least valid for one or two Alfven times exhibiting the initial stabilizing effect of the flow-shear. Retrospectively, this could have helped to explain the apparent absence of ballooning modes at the Troyon-Sykes limit in ISX-B, but on the transport level, ISX-B showed degradation of energy confinement clearly below the linear instability threshold!

8 Fussman (ASDEX) gave an introduction to neoclassical impurity transport theory and showed many experimental observations which agree with the neoclassical predictions of central impurity peaking, particularly for copper in ASDEX but questionable for carbon. On the other hand, certain observations disagree with the neoclassical predictions. For instance, in the L-mode, the impurity is much less accumulated than neoclassical theory would predict: There exists an anomalous flux in the L-mode which ceases in the enhanced confinement regimes. However, the neoclassical impurity transport theory used was based on only two ion species and the standard ordering scheme of the small Larmor radius expansion. For an impure plasma which has $\alpha \equiv n_i Z_i^2 / n_e \sim 1$, and $\Delta \equiv \delta_{ei} Z_i^2 \nu_{ii} / \omega_{ce} \geq 1$, the standard neoclassical theory can be strongly modified as was shown by Hsu and Sigmar at this meeting. This extended impurity theory also includes the nonlinearity from the $(\vec{v} \cdot \nabla)\vec{v}$ term important for the NBI induced toroidal plasma rotation. Thus, it is not yet clear what the full neoclassical prediction is for carbon.

9 Samain (Cadarache) also presented a neoclassical transport calculation using a new form of the variational principle based on minimum entropy production. For a trial function, he needs the first order solution from the drift kinetic equation which because of the complicated physics of the i-I collisions is not easy to obtain on the kinetic level. It was not clear from the talk if this new approach is practically useful to calculate the needed numerical coefficients of the transport coefficient matrix.

10 Behringer (University of Stuttgart) showed a detailed comparison between im-
purity accumulation in JET, and the 1-D time dependent transport modelling. The model uses the neoclassical transport flux prescription additive to an anomalous convective flux outside a variable radius \( r^* \). The conclusion is (that in the L-mode) a large anomalous flux is required to simulate the observed result but in the enhanced confinement mode the central peaking is neoclassical-like. The question whether it is justifiable to simply add an anomalous term to the neoclassical flux has yet to be resolved. Waltz and Scott doubt it.

11 Isler (ORNL) showed old material on ISX-B and some new material on TEXT of neoclassical-like impurity behavior, adding to the existing body of evidence.

12 Samm (TEXTOR) and Wagner (ASDEX) showed independent very systematic studies of the isotope effect on energy confinement. Both find obvious improvement of confinement in D plasmas compared to H plasmas. In the D plasmas, \( n_e(r = a) \) and \( T_e(r = a) \) are lower, but the profiles hardly change. Charge exchange differences can be ruled out. Various theoretical models for \( \chi_e \) scalings were tested against the data. None of the existing transport theories, including the turbulent transport theories, are entirely consistent with this observation. A most interesting change with ion mass of the fluctuation spectrum in otherwise similar ASDEX plasmas was shown by Wagner. However, he disqualified this data since the change in the spectrum was found to be caused by a change in gross MHD fluctuations.

13 Söldner (ASDEX) reported on LH discharges. He got amazingly high central \( T_e \) values of up to 10 keV.

14 Zohm (ASDEX) showed a very interesting experimental theoretical study of MHD mode locking and consequences for toroidal rotation damping. An \( m = 2 \) mode near the plasma edge interacts with the induced low mode number eddy current structure in the wall.
Final Discussion on Neoclassical Impurity Transport

A. Dr. Fussmann summarized several questions to theory which are collected here for the record. Both Samain and Sigmar-Hsu plan to address these topics:

1. Final agreement between Samain and Hirshman-Sigmar regarding certain numerical coefficients of transport matrix elements. (Samain gave Table 1, this report.)

2. In particular, there is a published jump of H (in the term $\Gamma_I \propto H \frac{T'}{T}$) from $-0.5$ to $+1.5$ (when $I$ is in the Pfirsch Schlüter (PS) and D goes from PS to plateau). What about different ion and impurity energy groups contributing differently? (In other words, what about simultaneous contributions from PS and from plateau regime ions?)

3. In cases where the experimental heat flux exceeds the neoclassical one, is the term $H \frac{T'}{T}$ in the particle flux still relevant?

4. Can one use $\Gamma_I = -(D_{neo} + D_{anom}) \frac{\partial n}{\partial r} - nV_{neo}$?

B. Dr. Wagner wanted to know which way one should better choose to improve energy confinement: (i) peaking $n_e$, using pellets or counter-injection; or (ii) flat $n_e$, using H-mode. In both cases, there is neoclassical-like impurity peaking. What to do about that?

C. It became quite obvious to these travellers that the ASDEX group "badly" needs to know more about (i) the sign (and $\nu_*$ dependence) of the above mentioned term $H \frac{T'}{T}$; (ii) the effects of the copper-carbon friction, to calculate the time dependent carbon profile (while Cu increases from a trace to the major impurity); and (iii) the influence of rotation on particle transport.

With the new "strong ordering theory" of Hsu-Sigmar, all of these questions are answerable more profoundly than before. While the theory has just been completed (and submitted for publication), applying it with the care warranted by the very strong ASDEX team interest will imply a major manpower commitment on the side of Hsu-Sigmar et al.
Itinerary

9/16/89  Boston – Munich
9/17/89  Weekend
9/18– 9/22/89  ASDEX meeting in Ringberg, West Germany
9/12/89  Munich – Boston

Total Expenses $914.40 (D. J. Sigmar)
Total Expenses $856.00 (C. T. Hsu)

Principal Persons Contacted

Drs. Wagner and Fussman, ASDEX
Dr. Engelhardt, MPIPP
Dr. Samain, Cadarache
Dr. V. Engelmann, NET-ITER
Dr. Grieger, MPIPP
Dr. D. Post, US-ITER team in Garching
Drs. Putvinski and Parail, Soviet ITER team
Table 1: Samain's Neoclassical Transport Coefficients in Various Mixed Collisionality Regimes

[The impurity flux is parameterized as \( \Gamma_I = -D \left( \frac{n^l}{n_H} - \frac{1}{Z} \frac{n^l_s}{n_s} + H \frac{T^l}{T} \right) \).]

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<th>( Z )</th>
<th>( H )</th>
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<th>Plateau (P)</th>
<th>Pfirsch Sch. (PS)</th>
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<td>( D = D_{PS} )</td>
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The numerical range given describes the \( Z_{eff} \) dependence, from \( Z_{eff} = 1 \) to \( \infty \).
APPENDIX A

ASDEX RINGBERG-SEMINAR 1989

Monday 09-18-89

Chairman: Wagner

9.55 - 10.00 Welcome, introduction and technical informations Wagner

10.00-11.00 An experimentalist's view of the turbulent transport in tokamaks Niedermeyer

11.00-11.30 Coffee break

11.30-12.30 Resistive tearing mode theory Giannone

12.30-14.00 Lunch break

Chairman: Carlson

14.00-15.00 The microtearing modes in tokamaks Samain

15.00-16.00 Drift wave theory (theory by experimentalist) Holzhauer

16.00-16.20 Coffee break

16.20-17.20 Lecture on drift wave theory - part I Scott

Depending on the time required for discussion one or both of the following talks will be given on Tuesday afternoon or in Garching

17.20-17.55 Fluctuations: A distribution of measurements is not a measurement of the distribution Carlson

17.55-18.30 Investigation of low-frequency density fluctuations in the edge plasma of ASDEX Rudyj

18.30 Dinner

Chairman: Gruber

20.15-21.15 Measurement of orthogonal conductivity in a tokomak and its relevance to the H - mode. Weynandts
Tuesday 09-19-89

Chairman: Holzhauer

9.00-10.00 Lecture on drift wave theory - part II
Scott

10.00-11.00 Ballooning modes with and without flow
Grassie

11.00-11.30 Coffee break

11.30-12.30 Lecture on turbulent transport in tokamaks - part I
Waltz

12.30-14.00 Lunch break

Chairman: Niedermeyer

14.00-15.00 Lecture on turbulent transport in tokamaks - part II
Waltz

15.00-16.00 Low frequency fluctuations and fluctuation induced transport in the ASDEX edge plasma and in a low pressure discharge
Krämer

16.00-16.30 Coffee break

If required one or both of the following talks will be given in Garching

16.30-17.30 Properties and confinement of sawtooth free discharges
Stroth

17.30-18.30 Viscosity and momentum confinement
Kallenbach

18.30 Dinner
Wednesday 09-20-89

Chairman: Lackner

9.00-10.00 Neoclassical impurity transport revisited  
Fussmann

10.00-11.00 Theoretical views on impurity transport in tokamaks  
Samain

11.00-11.30  
Coffee break

11.30-12.30 Impurity transport: peaking, up/down asymmetry, co- vs counter injection, bifurcation.  
Sigmar

12.30  
Lunch

Hiking

18.30  
Dinner
Thursday 09-21-89

Chairman: Engelhardt

9.00-9.35  Impurity transport theory using “strong ordering”  Hsu

9.35-10.35  Impurity transport in the presence of plasma rotation considering a compressible flow  Feneberg

10.35-11.00  Coffee break  Behringer

11.00-11.50  Impurity accumulation in JET- experiment and modelling  Lippmann

11.50-12.30  Impurity behaviors on DIII-D during H-mode  Lunch break

12.30-14.00  Chairman: Fußmann

14.00-15.00  Neoclassical - like impurity behaviour in ISX B and TEXT  Isler

15.00-16.00  Impurity accumulation in stellarators – results from Wendelstein VII  Weller

16.00-16.30  Coffee break  Krieger

16.30-17.30  Evidence for neoclassical impurity transport from ASDEX  Dinner

17.30-18.30  Discussion about neoclassical transport
Friday 09-22-89

Chairman: Söldner

9.00-10.00  
Studies of the isotope effect on TEXTOR

10.00-11.00  
Studies of the isotope effect on ASDEX

11.00-11.30  
Coffee break

11.30-12.30  
Power absorption and energy transport with LH

12.30-14.00  
Lunch break

Chairman: Leuterer

14.00-15.00  
Global energy confinement and profile modification with LH

15.00-16.00  
MHD mode locking and disruptions