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Phenomena in ionized gases : some reflections on the XIVth ICPIG

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Abstract. — This paper reviews the scientific program of the XIVth ICPIG, held in Grenoble, 9-13 July 1979. It analyzes the distribution and contents of the roughly 425 contributed papers, and discusses the format of the program at this and previous ICPIG's.

1. **Introduction.** — Although an authoritative review of the 450 papers of the Conference, indicating their scientific merits, practical significance, and likely impact, would be very valuable, I shall not attempt to give one. Even if I possessed the requisite expertise in all of the fields of the Conference, I would hesitate to do so, since judgments about scientific quality and predictions of the future are notoriously difficult to make.

The further element of personal danger in singling out names for special mention is not to be disregarded lightly. Louis XIVth remarked bitterly that every time he chose someone he made *cent mécontents et un ingrat* (one hundred people discontented and one ungrateful), so I shall steer the safer course in this review of mentioning only one speaker by name.

Instead of an Olympian review, I shall examine first the areas of concentration of the roughly 425 contributed papers. This is not to confuse quantity with quality, but rather to establish the scientific topics of interest to the nearly 450 participants, and to provide food for thought as the International Scientific Committee (ISC) begins in earnest its planning for the XVth ICPIG. Second, I shall discuss the format of the scientific program, and some alternatives to it that have been used at past ICPIG's. My aim is to stimulate thought on the matter, and suggestions to the ISC.

2. **Contributed papers.** — Contributions were invited in fifteen categories. Counting 20 papers/star, a *Guide Michelin* to those papers accepted would give :

*** — Waves (65 contributions).
— High pressure discharges (64).
— Elementary processes in gas discharges (60).
** — Low pressure discharges (54).
— Diagnostic methods (45).
* — Interaction of laser beams with plasmas (22).
— Surface phenomena (21).

Lest too much significance be attached to this list, we note that the numbers are approximate to the extent that a few authors may not have been present, or may have withdrawn their papers, and that the classification is somewhat arbitrary : some papers could be appropriately classified in more than one category. Further, as we shall see later, some other categories are close to those mentioned above, e.g. Discharges for Lasers. Nevertheless, we may conclude that three-quarters or more of the contributed papers belong to the seven categories listed.

We now examine the fifteen categories in greater detail, indicating subdivisions originally listed by the ISC, and some additional subdivisions (in parentheses) suggested by the contributions actually received.

2.1 Elementary processes in gas discharges (60)

a) Excitation and ionization.
b) Recombination, attachment and detachment.
c) Ion-molecule and chemical reactions.
d) [Velocity distributions, swarms, avalanches.]

About 50 papers were divided roughly equally among categories 1*a*)-*c*). The remainder concentrated on the topics of category 1*d*) : self-consistent calculations of velocity distributions in glows, afterglows and hollow-cathode discharges ; swarms, and avalanches.

2.2 Low pressure discharges (54)

a) Positive columns.
b) Ionization waves and instabilities.
c) Negative glow, hollow cathode discharges.
d) Radio frequency discharges.
e) Townsend discharge, breakdown and pulse discharges.
f) [Isotope separation.]
g) [Sheaths.]

Many of the papers from this category could arguably have been placed in category 1 or category 10

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(Waves). Most of the papers fell within categories 2*a*)-*e*), with no strong themes emerging, but special mention might be made of several contributions outside these subdivisions motivated by isotope separation, and several more devoted to sheaths and double-layers.

2.3 HIGH PRESSURE DISCHARGES (64)

a) Sparks, breakdown, corona discharge.
b) Properties of arc plasma; arc dynamics.
c) Plasma flows.
d) Chemical reactors.

This category is very broad, including not only widely-differing established discharges (corona and arcs), but also the transient breakdown phase, and plasma chemistry. The principal thrusts among the contributed papers were in the directions of decaying arcs, breakdown and corona, and arcs in transverse and axial flows. These studies have particular applications to high-voltage devices and circuit-breakers.

2.4 DISCHARGES FOR LASERS (17)

a) [Discharge characteristics.]
b) [Basic processes.]
c) [Waves and instabilities.]

The contributions in this category were approximately evenly divided among categories 4*a*)-*c*), and separable from categories 1, 2, and 10 primarily by their motivation, i.e. the various radiation processes and discharge instabilities likely to affect laser performance were of particular interest.

2.5 DISCHARGE AND BREAKDOWN IN VACUUM (8)

a) [Surface phenomena.]
b) [Effects of magnetic field.]

Two topics that have figured prominently in this small category are surface phenomena affecting breakdown, and the effects of magnetic fields in switching or extinguishing vacuum arcs.

2.6 LONG SPARKS AND LIGHTNING (6)

No special theme emerges from this small category, which might well be combined in future with categories 3*a*) and 5 to form a single category on spark breakdown and lightning.

2.7 SURFACE PHENOMENA (21)

a) Electrode phenomena.
b) Surface treatment using plasma (deposition, etching, oxidation, etc.).

This substantial category could arguably be augmented with a number of contributions dispersed through others. Those papers actually included emphasized category 7*a*), and included several papers on arc spots and cold cathodes; still an interesting area, even after several hundred publications.

2.8 MISCELLANEOUS DISCHARGE DEVICES (16)

a) [Special types of discharges.]
b) [Discharges for ion or neutral production.]
c) [Rotating plasmas.]

This rather desperate category is intended as a catch-all for contributions on devices not fitting readily into any other category. In fact, several papers could have been placed elsewhere in the program, but a residuum remained of papers on unusual discharges, some serving special purposes such as ion or neutral production, and a few on phenomena associated with rotating plasmas.

2.9 GENERAL PLASMA THEORY (15)

a) Transfer phenomena.
b) Numerical methods.
c) [Kinetic equations.]
d) [Distribution functions and drifts.]

No contributions were received in category 9*b*), though papers involving sophisticated numerical methods are to be found elsewhere, for example in category 15 (Diagnostic Methods). If we consider category 9*a*) to refer primarily to macroscopic phenomena, then other concentrations among the papers contributed were on kinetic equations, and the velocity distribution functions and drifts predicted for various special discharges.

2.10 WAVES (65)

a) Wave propagation.
b) Wave-particle and wave-wave interactions.
c) Instabilities.
d) Strong turbulence.
e) [Solitons.]

Although the contributions to this large category defy neat classification, certain trends are evident. Many intriguing problems in linear wave excitation, instabilities and propagation, particularly in bounded plasmas, still command attention, but the emphasis has moved towards nonlinear parametric and modulational instabilities and turbulence. Solitons, which in all fields now generate about 1 000 publications a year, have gained considerable significance in plasma physics, a fact which was reflected by several interesting papers, including experimental observations.

2.11 NON-IDEAL PLASMA (12)

a) Theory.
b) Experiment.

Although a cynic might be tempted to place all of the contributed papers in this category, it was intended for plasmas sufficiently dense for quantum effects to become significant. Growth of interest in this area is evidenced by the number of contributions received, several of which described experimental observations.

2.12 ASTROPHYSICAL PLASMAS (12)

a) [Basic processes, radiation.]
b) [Waves and instabilities.]

This category represents another growth area for the Conference. No strong theme emerges ; contributions covered basic processes involving excitation and radiation, the slowing down of charged particles, wave instabilities and shocks.

2.13 INTERACTION OF LASER BEAMS WITH PLASMAS (22)

a) Laser-induced plasmas (optical discharges).
b) [Plasma target.]
c) [Electrode target.]
d) [Pellet target.]

The general category 13*a*) might be taken to include topics from gas breakdown by lasers to interaction with any form of plasma or solid target. In fact, most of the contributions may be classified best in categories 13*b*)-*d*), and in many cases are motivated by laser fusion.

2.14 INTERACTION OF PARTICLE BEAMS WITH PLASMAS (7)

a) [Inertial confinement.]
b) [Beam-plasma interaction.]
c) [Undulator.]

Similarly, interests in beam-induced fusion with inertial confinement motivated papers in category 14*a*). Those in category 14*b*) might well have been placed in category 10*c*). The paper on high frequency generation by a relativistic electron beam traversing a sinuous waveguide (undulator) describes a phenomena of great interest, but which is not strictly a beam-plasma interaction.

2.15 DIAGNOSTIC METHODS (45)

a) Probes.
b) Spectroscopy.
c) Miscellaneous.
d) [Laser scattering, interferometry and holography.]
e) [Microwaves.]

This category, which could undoubtedly be augmented with papers dispersed through many others, is always one of the most significant areas of the Conference. A natural sequence of events in the development of science is first to observe basic physical phenomena accurately, then to model and describe them precisely, and finally to use them in the form of diagnostic techniques. In that sense, the category of Diagnostic Methods illustrates a number of phenomena for which the quality of scientific description is high.

Probes now provide only a small number of contributions. A more significant number concerned various aspects of spectroscopy, including light sources and standards. The most notable growth, however, was shown by optical techniques involving laser scattering, interferometry and holography. In contrast to many spectroscopic techniques, the discharge is actively probed with a controllable source.

A similar comment applies to the several microwave diagnostic techniques reported. A further advantage of both over invasive techniques such as probes is that they permit measurements to be made from outside the discharge.

3. **Format of the scientific program.** — As the Conference has evolved from its small beginnings in Oxford 26 years ago, a persistent problem for the ISC has been the choice of format for the scientific program. Many of us believe that the best conferences for developing personal contacts and exchanging information are those at which some 75-100 participants meet for a few days, preferably in a remote place, give few papers, and spend most of the time in discussion.

Larger conferences, such as the ICPIG, make it harder for groups of participants with close mutual interests to maintain contact and follow a scientific thread through parallel sessions, but can offer a much wider perspective on the field and the opportunity for more numerous personal contacts.

The ISC attempts to construct an optimal program, combining the virtues of large and small conferences, using the following elements :

— General Invited Lectures.
— Topical Invited Lectures.
— Contributed Papers.
Oral Sessions.
Poster Sessions.
— Rapporteur Sessions.
— Discussion Sessions.
— Post-deadline Papers.

The respective merits and defects of these elements, and the ways in which the ISC has chosen to deploy them in recent ICPIG's, are worth examining.

General invited lectures. — These are intended to be authoritative general-interest reviews of broad fields, some not otherwise emphasized at the Conference, and are given in plenary sessions. It is consequently necessary to find distinguished scientists willing and able to prepare such reviews in written form, as well as for oral presentation. They must discuss work beyond that carried out in their own groups, and since simultaneous translation facilities are not usually available must generally be prepared to do so in English.

Choosing such scientists is a difficult commission. About ten has been the recent aim, and without wishing to seem self-congratulatory, it can be said that the ISC has assembled a wide-ranging and impressive list at Grenoble, headed by Prof. Alfvén, *primus inter pares*, at the Opening Session :

Theme 1 (= Laboratory and Natural Plasmas).

Plasmas in the Laboratory and in Space (H. Alfvén).

Ion-Molecule Interactions in the Laboratory and in Planetary Atmospheres (H.S.W. Massey).

Theme 2 (= Natural Plasmas).

Lightning (K. Berger).

The Solar Flare Phenomenon (J. Heyvaerts).

Theme 3 (= Laboratory Plasmas).

Contact Electrode Processes and Microplasma Diagnostics (F. L. Jones).

Strong Turbulence and its Computer Simulation (V. E. Zacharov and Y. S. Sigov).

Particle Beam Interactions with Plasmas and their Application to Inertial Fusion (M. J. Clauser).

Progress in Toroidal Magnetic Confinement (G. Grieger).

Progress on Laser Fusion at Lawrence Livermore Laboratory (H. G. Ahlstrom).

Topical invited lectures. — These satisfy criteria of quality and style similar to those for General Invited Lectures, but are intended to be more specialized, and hence less appropriate for presentation in plenary sessions. They are consequently scheduled in competition with contributed papers, but not with each other. Twelve such lectures were invited by the ISC for the Grenoble Conference.

Contributed papers. — The greatest pressure on the ISC derives from the large number of contributed papers. In the past, half a dozen parallel sessions have been necessary to accommodate them all as oral presentations, or rapporteur sessions (see below) have been organized to review them in groups. There have been suggestions that the scope of the Conference should be restricted, but this militates against the aim of offering to participants a broad perspective on phenomena in ionized gases.

Rather than explicitly excluding certain areas, the ISC has chosen to solicit papers according to a list of topics which evolves following the interests shown by participants at previous conferences, and currently includes the 15 categories discussed in § 2. The result is that topics such as thermonuclear fusion, MHD energy conversion, ionospheric physics and astrophysics, which are catered for by a variety of other conferences, figure less prominently among the contributions and are typically covered by invited lectures.

At the East Berlin and Grenoble conferences, the ISC agreed to limit the oral presentation of contributed papers to two parallel sessions, so effectively limiting the numbers of oral presentations to about 75. This method of avoiding the conflicts of multiple parallel sessions has been made feasible by the organization of poster sessions running parallel to the oral sessions.

In recent years, poster sessions have become popular at many national and international conferences. At first, some authors were apprehensive that presentations by poster constituted a second-class mode of communication. It rapidly became clear that this is not the case : they help to identify people interested in your work and egender personal contacts with them, they are a boon to inexperienced speakers, or in situations where there are language difficulties, and they are superior to brief oral presentations when large quantities of data or numerous equations are to be displayed.

As an example, we may take the Annual Meetings of the Plasma Physics Division of the American Physical Society. Opinion has swung in the last three years to the position where the majority of authors now opt for poster presentation of their work. At Grenoble, the ISC had to select about 75 out of 425 contributed papers, using as criteria the nature and scientific interest of the material, and the desirability of presenting a wide range of topics. It is possible that this process would have been unnecessary had authors been asked to state their preferences at the time of submission.

Before leaving the topic of Contributed Papers, a heavy debt of gratitude should be acknowledged to the Local Organizing Committee, and to their small army of helpers who reviewed the contributed papers. The separation into coherent sessions for oral and poster presentations and their timing on the scientific program to avoid conflicts are further onerous tasks whose outcome is never perfect. The ISC exercises final judgment and responsibility in such matters, and in the rejection of papers that are irrelevant to the Conference, of dubious scientific quality, or of impenetrable obscurity, but relies on the Local Organizing Committee for the initial groundwork, and ultimate detailed execution of its wishes.

Rapporteur sessions. — For some previous ICPIG's, rapporteurs were selected in advance to comment on groups of papers. This procedure saves time, and ideally presents a series of integrated, critical reviews of the contributed material. In practice, its aims and advantages are difficult to realize. First, the material for a rapporteur session must be sufficiently concentrated about a theme to lend itself to coherent review. Second, it is difficult to find people willing to put in the considerable time and preparation needed for successful rapporteur sessions. Third, it is sometimes difficult to supply them with the contributed papers sufficiently far in advance of the Conference for such preparation to be feasible. For these reasons, the ISC has abandoned rapporteur sessions for the present in favor of poster presentations.

Discussion sessions. — At previous ICPIG's (though not at Grenoble), discussion sessions on special topics, organized during the Conference by interested groups, have constituted a prominent feature of the scientific program. The ISC will continue to provide facilities for such meetings since they represent a valuable

means of exchanging recent information, and speculating informally on emerging topics.

Post-deadline papers. — With a similar aim in mind, the ISC has provided facilities at Grenoble for poster presentation of very recent, or highly speculative, results. They are presented at the discretion of their authors, and of course do not appear in the Conference Proceedings.

4. **Future conferences.** — If any justification is required for the continued existence of the ICPIG, it is provided by the large numbers of participants and presentations at Grenoble : about 450 of each. If the Conference ceased to exist, it would certainly be missed by the substantial core of participants who follow it regularly, and would probably be rapidly reinstituted in a comparable form.

It is the responsibility of the ISC to maintain the vitality of the Conference, and to be continually open to suggestions for improvement in its form and detailed organization. Work on the XVth ICPIG in Minsk, in July 1981, has already begun, so your comments and suggestions are earnestly solicited. Please write to me or any other ISC member concerning the scientific program, or to Prof. Tsytovich concerning matters in the province of the Local Organizing Committee.

We know that there is no persistent ideal format for a conference such as the ICPIG, and that in practice its success depends on the constraints and happy accidents of time, place, organizers, scientific contributions, and participation. To that extent, *We live not as we wish to, but as we may,* as Menander remarked, and even the most heroic efforts of the ISC cannot ensure universal satisfaction.

On the other hand, the ISC has a very deep concern for the welfare of the Conference, and a wealth of experience of it (to say nothing of extraordinary modesty !). For example, although none of us can match the record of the outgoing chairman, Prof. Maecker, of having attended all fourteen ICPIG's, three of us have participated in ten, and all past ICPIG's have been attended by at least one member of the new ISC. Their experiences include memories of promising improvements in the Conference that have not succeeded, and risky experiments that have worked very well. If some of your suggestions for improvements are not adopted, it may be because of such experiences; you can be sure at least that they have not been ignored.