# AIP CONFERENCE PROCEEDINGS 345

# INTERNATIONAL CONFERENCE ON PLASMA PHYSICS ICPP 1994

**FOZ DO IGUAÇU, BRAZIL**
**OCTOBER-NOVEMBER 1994**

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AIP PRESS
**American Institute of Physics** **Woodbury, New York**

# SUMMARY OF BASIC PLASMA PHYSICS AND APPLICATIONS

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## 1. CONFERENCE STATISTICS

Is basic plasma physics still alive, and if so, where is it being pursued? Some answers to these questions can be found in the statistics of the papers presented at this conference. The contributed papers were divided into the 13 subject areas shown in Table I.

**Table I: Subject Areas**

| | |
|---|---|
| **TS:** | Tokamaks and Stellarators |
| **AS:** | Alternate confinement Systems |
| **HC:** | Heating and Current drive |
| **PE:** | Plasma Edge physics |
| **IC:** | Inertial Confinement fusion |
| **SP:** | Space Plasmas |
| **AP:** | Astrophysical Plasmas |
| **GT:** | General plasma Theory |
| **GD:** | General plasma Diagnostics |
| **PI:** | Partially Ionized plasmas |
| **EP:** | Elementary Processes |
| **BC:** | Basic Collisionless plasmas |
| **PA:** | Plasma Applications |

The last six of these areas (GT, GD, PI, EP, BC, and PA) concerned basic plasma physics and applications, especially the last four, with a few contributions from areas AS, PE, and IC. For the six areas concerned, Table II shows the number of abstracts submitted, the number of written papers delivered, and the number of papers actually presented. In addition, of the 56 plenary and invited papers, 10 were on basic plasma physics and applications, and two were on related subjects. Though fusion dominated the invited talks, these were mainly reviews of the major installations for the benefit of the participants.

**Table II: Statistics of Poster Papers**

| Poster Session | Abstracts | Papers | Actually given |
|---|---|---|---|
| GT 1,2,3,4 | 79 | 48 | 23+ * |
| GD 1 | 24 | 16 | 15† |
| PI 1,2 | 31 | 19 | 16 |
| EP 1 | 18 | 12 | 12† |
| BC 1,2 | 49 | 34 | 25 |
| PA 1,2 | 33 | 27 | 25 |

*Count of General Theory papers is incomplete, since many were not to be included in this summary.
† Includes postdeadline papers.

**Plenary and Invited Papers**

| | |
|---|---|
| On basic plasma physics: | 10/56 |
| On related subjects: | 2/56 |

From Table II we can draw several conclusions. Only about half of those intending to come to ICPP'94 actually made it, probably because of financial difficulties and the remoteness of the site. It is encouraging, however, that a comparatively large number of papers on basic plasmas and applications, particularly applications, were actually delivered. This may show a shift of interest toward practical uses of plasma physics.

Further insight can be gained from the geographical distribution of the origin of the papers enumerated in Table II; this is shown in Table III. These numbers indicate not only the existence of basis research, but also the availability of adequate funding for the presentation of results.

**Table III: Geographic Distribution of Basic Plasma Papers**

| | Poster | Invited |
|---|---|---|
| **Japan** | **26½*** | **2** |
| **South & Central America** | **38½** | **2** |
| Brazil | 25 | 1 |
| Argentina | 6 | |
| Mexico | 3 | |
| Venezuela | 3 | |
| Colombia and Chile | 1½ | 1 |
| **Western Europe** | **20** | **2** |
| Austria | 6 | 1 |
| Germany | 5½ | |
| Italy | 3 | |
| Denmark, Sweden, Norway | 4½ | 1 |
| Portugal | 1 | |
| **North America** (USA) | **4** | **1** |
| **England** | **2½** | |
| **India** | **5** | **1** |
| **Former Soviet Union** | **5** | **2** |
| **Australia** | **2** | |
| **South Africa** | **2** | |
| **Egypt** | **2** | **1** |
| **Czech, Romania** | **1** | **1** |
| **Israel** | | **1** |

* Fractions indicate multiple authorship.

We see that basic research is still actively pursued in Japan, and that many have found the means to travel from Japan to Brazil. It is encouraging that Japan is still able to support basic research in spite of its heavy commitment to fusion. Considerable activity in basic research is to be found in South and Central America, though the numbers here are biased in favor of Brazil, not only because of proximity, but also because of special government support for travel to this conference. The number of papers from Western Europe and the UK is lower than usual, and that from the U.S. has dropped off precipitously, owing to the budgetary difficulties there. As always, there are papers from countries all over the world. Plasma science is widely studied. Indeed, the ICPP is one of the few conferences in which plasma physicists from Third World countries can present their work to an international audience.

## 2. SELF-ORGANIZATION

The diversity of topics presented here makes it difficult to name one single new result that stands out as a highlight of the conference. If forced to choose, I would cite the advances in our understanding of the self-organization of plasmas. It has been 20 years since J.B. Taylor proposed his minimum energy state based on the conservation of helicity, a theory that lies behind work on reversed-field pinches. Tests of this theory can now by made by computer simulation and in experiment, with the result that the idea is basically confirmed, but with modifications in the details.

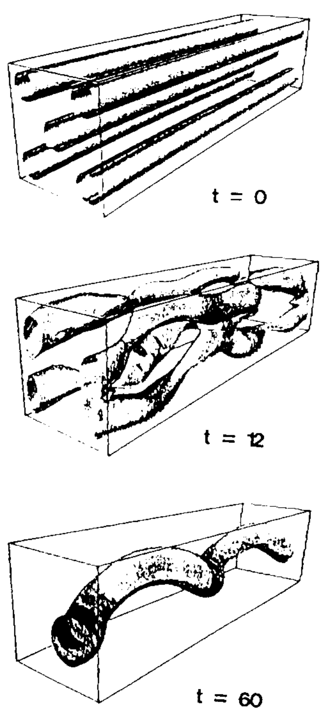


**Fig. 1**

An invited paper by T. Sato of the NIFS in Nagoya, Japan summarizes a large body of 3D computations clarifying the mechanisms of self-organization. If a plasma is initially energized and is allowed to relax, the tubes of current shown in Fig. 1 reconnect with one another and finally reaches a minimum-energy helix. The helicity falls during the process and reaches a steady value, while the energy falls through an intermediate state. If energy is continuously supplied to the system, instability occurs to expel the excess energy. If energy is supplied and removed at the same rate, the system twists into a minimum energy state but does not stay there; the state recurs intermittently. The behavior of the system depends on the mechanism of excess entropy removal.

An experimental study of self-organized structures and the conservation of helicity was presented by Urrutia, Stenzel, and Rousculp [Proceedings, Vol. **3**, p. 257]. In the apparatus shown in Fig. 2, several cubic meters of plasma is produced in a 10-G magnetic field, and a negative voltage pulse is applied to the electrode on the left to start a flow of electron current to the opposite end. However, the current does not flow directly from left to right; rather, the current paths form force-free structures which end at various parts of the wall. These current paths tend to form knotted ribbons (Fig. 3). The helicity $\iint \mathbf{A} \cdot \mathbf{B}\, dS$ integrated over a cross section decays from left to right because of dissipation, but the *normalized* helicity $\iint \mathbf{A} \cdot \mathbf{B}\, dS \,/ \iint AB dS$ remains constant (Fig. 4), showing that the topology does not change. (Here **B** is the magnetic field and **A** its vector potential.)

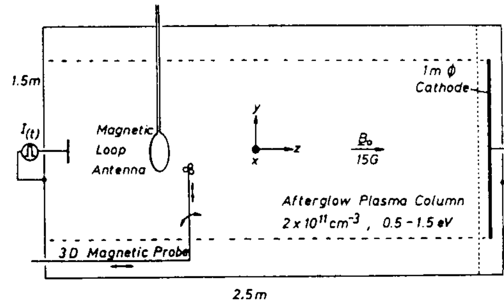


Fig. 2

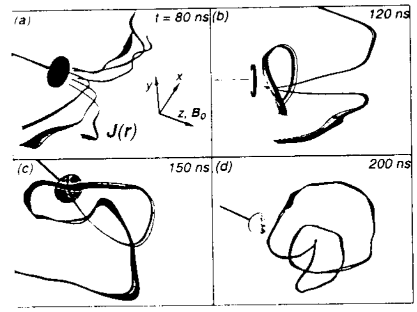


Fig. 3

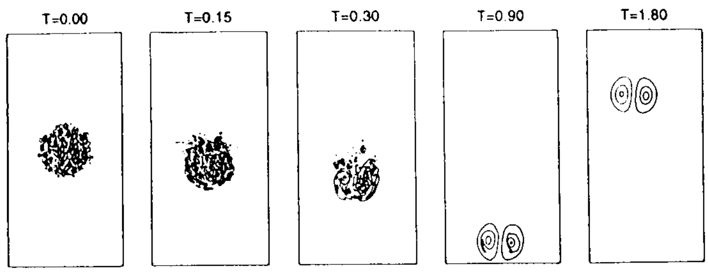


Fig. 5

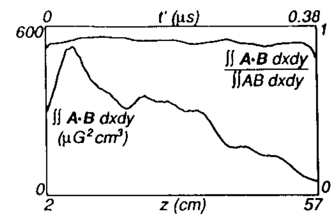


Fig. 4

A different kind of coherent structure is treated in an invited paper by Rasmussen et al. of Denmark. Two-dimensional flows in hydrodynamics and in strongly magnetized plasmas follow the same equations and can be treated together. Fig. 5 shows how a turbulent patch evolves into a dipole vortex structure in a homogeneous medium. These studies apply equally well to convective cells in fusion toruses and to planetary atmospheres.

## 3. BASIC EXPERIMENTS

**Dusty plasmas.** The study of plasma comprising or containing charged particulates is a relative newcomer among the traditional topics for basic plasma physics. It has been known for several years that dust in plasmas is important in two different arenas: in the solar system, where dust grains affect the behavior of comet tails and planetary rings; and in plasma processing, where micron-sized contaminants are a major source of defects. More recently, several groups have found dust to provide an easy way to study strongly coupled plasmas, those which have less than one particle per Debye sphere. Since dust particles can have charges of order $10^4 e$ or above, this condition is easily produced. In an invited paper, Merlino reported on an experiment of the Iowa group in which a "solid" plasma, or Coulomb lattice was directed observed. In Fig. 6, a Q-machine plasma is surrounded by a perforated drum containing 10-μm particles which are dropped into the plasma as the drum rotates. By applying a high voltage to an anode, a cone-shaped double

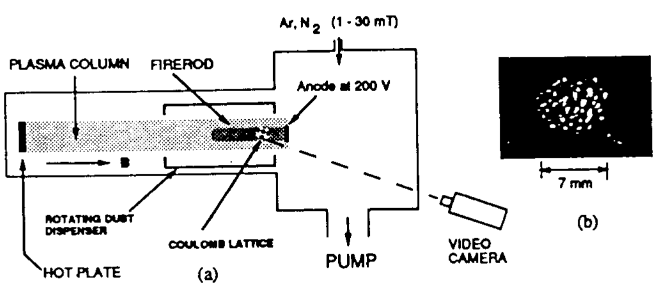


Fig. 6

layer is formed, and the dust grains, which are charged negative like floating probes, are trapped in the potential maximum. A video camera shows the motions of the dust particles in this "firerod" as they keep their interparticle distances at a fixed value.

Other papers on dust include ones from Belgium and Japan. F. Verheest of Belgium (**2**-286) points out that, since the charge Q on dust grains does not have to be constant, fluctuations in Q induced by a wave can feed back and cause an instability of the wave. T. Taziuti of Japan (**2**-282) shows a method for measuring the charge Q employing an electrostatic deflector. The particles are of evaporated silver with a measurable radius, so that their mass is known. The result of $Q \approx 900e$ agrees with the value Q = CV, where the capacitance C is given by the radius and V is the floating potential.

**Solitons.** One of the first nonlinear phenomena to be studied, acoustic solitons have been the subject of many experiments for the past 25 years. Several papers at this conference showed that interesting basic work on solitons is still going on. For instance, Nakamura and Kurahashi of Kanagawa, Japan (**3**-193) used a double-plasma machine, as is normal for soliton experiments, but added $SF_6$ to the Ar plasma to give negative $F^-$ ions and also added a separate ion beam source which was insulated from the main plasma by ferrite magnets in its casing (Fig. 7). This allowed them to create both positive and negative solitons and to amplify them by ion-ion interaction with the beam. Both linear waves and solitons could be amplified, but the solitons were amplified only when the component of the ion beam velocity in the soliton direction was above about twice the acoustic speed. Hellberg of the Univ. of Natal in South Africa reported on theoretical work by Gray, Hellberg, Verheest, and Mace (**2**-327) on solitons in four-component plasmas consisting of electrons and positrons, each with a hot and a cold species. It was found that if all the species had a Boltzmann distribution, only small-amplitude solitons can exist.

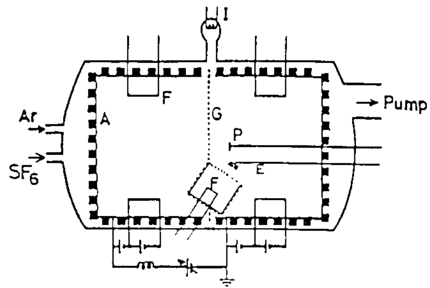

**Fig. 7**

**Double-layers.** The discovery of double-layers in the ionosphere triggered numerous experiments in double-plasma devices both in the US and in Scandinavian countries. This activity has greatly subsided or was not well represented at this conference. Two Japanese papers bore on the subject. Tonegawa, Kawamura, and Takayama (**3**-65) demonstrated the production of a current-free double layer by a $LaB_6$ hollow cathode discharge. Honzawa, Sekizawa, and Nagasawa (**1**-281) measured the distribution function of ions trapped in a potential well in a double-plasma and showed how such ion clouds could distort the results from large gridded energy analyzers. A Swedish experiment by Gunnell is described in the next section.

**Electron beams.** Beam-plasma interactions have continuously been subject to basic experimentation since the late 1950s in many countries. New phenomena are still being discovered. It has been known for some time that as the current of an electron beam in increased, violent disruption of the current eventually occurs, presumably because of the formation of a double layer. These disruptions have been difficult to study because they occur randomly, just as tokamak disruptions do. In an experiment reported by Gunnell, Brenning, and Torvén (**1**-273), a special double probe is designed to detect plasma oscillations during bursts of ra-

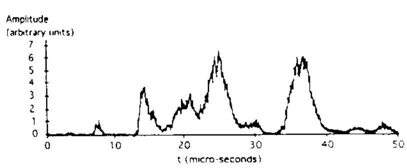

**Fig. 8**

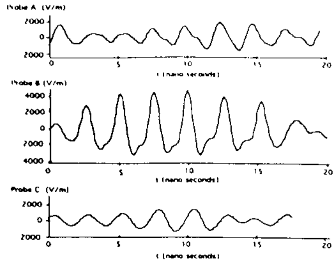


**Fig. 9**

diation. The probe consists of two thin wires 0.5 mm apart, connected to coaxial cables leading to circuitry giving the difference voltage. To minimize both pickup and disturbance, the wires are formed into a twisted-spiral section before they enter the probe shaft. These probes can be calibrated and respond to the 400-MHz plasma frequencies in the $10^9$ cm-$^3$ plasma. The plasma is created between a ring anode and ring cathode, and a double layer is formed by drawing current to a central anode. Bursts of radiation are seen near the double layer, as shown in Fig. 8. These bursts consists of localized plasma waves, as shown by the signals on three probes (Fig. 9). Note that the amplitudes are of order kV/m, though the double-layer voltage is only 27 V. The threshold for Langmuir collapse, however, is 6 kV/m, and the bursty nature of the waves is attributed instead to electron trapping. A magnetic mirror was used to stabilize the double-layer position, but it is not clear whether or not a magnetic field is necessary to produce the bursts.

In the experiment of do Prado et al. of Brazil (**3**-217), a planar e-beam is created by biasing the source chamber of a double-plasma device negatively. Only a surface magnetic field is present. The beam relaxation length L is measured, and its behavior attributed to Langmuir turbulence without direct observation of the plasma oscillations. The length L at first falls as $(n_b/n_o)^{-1}$, as predicted by quasilinear theory, then reaches a plateau as modulational instability sets in, forming cavitons by the ponderomotive force of the assumed Langmuir waves. Finally, for larger beam densities, L falls as $(n_b/n_o)^{-1/2}$ as the modulational effects develop. A double plasma was used to generate the beam-plasma interaction also in the paper of Hayashi et al. of Kyushu University (**3**-33), but here the high-frequency waves in the 150-Mhz regime were directly observed. They had a complicated frequency spectrum and formed a standing wave pattern in the experimental region. By launching test waves, it was found that waves below $\omega_p$, with frequency $\omega_p[1-(n_b/4n_0)^{2/3}]$ due to the beam-plasma interaction were generated at the center of the chamber, while Bohm-Gross waves with $\omega > \omega_p$ were generated near the wall.

The surprisingly simple experiment of Varma et al. of India (**3**-121) yielded the most baffling result. Here, a weak beam of only a few nA was projected across a distance $L \approx 50$ cm of vacuum along a 78G magnetic field to a grounded grid and collector. As the beam energy was varied from 100-500 eV, the collected current showed peaks and dips, with peaks occurring at energies $E_j$ which follow the relation $E_j = \frac{m}{2}\left[\frac{f_c L}{j+\phi_j}\right]^2$, where $f_c$ is the electron cyclotron frequency, $j$ is an integer and $\phi_j$ is a small phase correction. This formula had previously been given by Varma, but the fact that the grid and collector currents were anticorrelated probably indicates that the explanation is not so simple.

**Waves and instabilities.** Though it is difficult to find new problems with linear waves and instabilities, many problems remain with waves that are not quite linear. Tsukabayashi et al. (**3**-253), using a double-plasma device, found that a large-amplitude ion acoustic wave train in a 3-G magnetic field excites a 2nd harmonic wave bunch behind it. We think that the halved wavelength is probably caused by the periodicity of the ponderomotive force of the original wave. Takeda et al. (**3**-245) claim to have seen the Buneman instability in a magnetized deuterium plasma generated by a Ti washer gun. When a capacitor discharge is fired along the field, capacitive probes see UHF signals in the 350-MHz range, in agreement with Buneman theory. Morales et al. (**3**-189) reported on Alfvén wave experiments by Gekelman et al. at UCLA, in which the waves are confined to channels as narrow as an electron collisionless skin depth. In doing the theory for this case, they found the new phenomenon of collisionless diffraction in radiation cones.

## 4. BASIC THEORY

**Chaos.** The field of nonlinear dynamics has its growth spurt about a decade ago when bifurcations, attractors, and chaos were discovered with fast computers. Several papers indicated that this field still holds interest for many practitioners. Corso and Rizzato (**2**-21) considered bifurcations in a relativistic wave-particle system, and Pakter et al. (the same people) did the same for a cyclotron maser system (**2**-131). Spatschek and Eickermann (**2**-155) showed that even in weakly ionized plasmas, drift-type instabilities can lead to chaotic convective transport across a magnetic field. Serbeto et al. (**3**-229) studied the chaotic behavior of a relativistic electron beam interacting with a slow transverse electromagnetic wave. Tanaka et al. (**3**-249) computed the chaotic acceleration of electrons by electron cyclotron waves.

**Laser-plasma interactions.** What has happened to inertial fusion and laser-plasma interactions? A hot topic not so long ago, this field was poorly represented at this conference. Worldwide interest is still strong, but the ICPP is not a major conference for this field. Most of the submitted posters were not given. On the experimental side, there were only a few papers on the fabrication of microballoons. On the theoretical side, there was an invited review by T. J. M. Boyd of the UK and two interesting poster papers. The first, by Barr, Boyd, et al. (**1**-77), considers strongly driven Raman backscattering in sub-picosecond pulses. The advent of short-pulse lasers of extremely high brightness has necessitated a new approach to the theory. The interaction length is now limited by the length of the laser pulse itself, and computations are done in the moving frame. There is mode conversion at the boundaries. Linear dispersion relations no longer hold because of the strong coupling. What is needed is a global treatment which includes all parametric processes at the same time. This paper purports to explain the baffling observations of a blue shift of the scattered light. On a different subject, Sakagami and Nishihara (**1**-249) gave 3D simulations of the Rayleigh-Taylor instability in laser-fusion targets. It was found that, surprisingly, three-dimensional distortions of the surface grew faster than 1D or 2D perturbations. The sphere deforms into a cluster of bubbles. Such effects as the vorticity at the bottom of the bubbles are needed to explain this computational result.

**Other topics.** Of the large number of theoretical posters submitted, a majority were not given or merely posted in the absence of the author. Of the remainder, we cite only a few random ones of general interest. Simpson and Law of Australia (**3**-53) treated a problem that is important now that industrial uses of gas discharges are becoming more prevalent. These discharges usually contain noble gases possessing a Ramsauer minimum. The motion of electrons in gases with a non-monotonic cross section is not easily treated using normal methods, and this paper tackles this important problem. Mace and Hellberg of South Africa (**2**-95) solved the fundamental problem of the plasma dispersion function (Z-fn.) in a plasma containing superthermal particles. Jiménez-Domínguez of Mexico (**3**-181) found a clever use of the Z-fn. that does not involve plasma physics at all. Noticing that the Hilbert transform of the Voigt profile of a spectroscopic line is identical to the real part of the Z-fn., he was able to use the standard methods for approximating the Z-fn. to evaluate the integrated intensity of a spectral line. Riemann of Germany (**2**-139) considered the problem of the Bohm sheath criterion in the frequently occurring case where there are several ion species in the plasma. He found that the equation giving the critical ion velocity had a singularity for each ion species, but that only the one corresponding to the lightest ion was relevant.

## 5. PLASMA PROCESSING

Applications of partially ionized plasmas played a major role in this conference for the first time as a strong showing was made by many countries in the poster sessions on this subject.

**Plasma sources.** In addition to papers on the "standard" methods for producing plasmas for industrial applications, it was refreshing to see novel ideas that are not presented in the major conferences devoted to this field. An invited paper was given by Y. Kawai on the work at Kyushu Univ. in Fukuoka, Japan, on producing plasmas in the $10^{12}$-$10^{13}$ cm$^{-3}$ density range, uniform over >20 cm diameter, using electron cyclotron resonance (ECR). A slotted waveguide is used at the standard frequency of 2.45 GHz. Fukao of Japan (**3**-89) showed a large ECR discharge with linear multipole surface magnetic confinement. The resonance zones at 875 G, where $\omega = \omega_c$, are located at the cusps; and the plasma diffuses into the field-free interior, where the density becomes uniform. Though this large machine requires too much power for practical uses, the concept could be used in small devices using permanent magnets. Chen et al. (**3**-21) and Krämer et al (**3**-37) reported on basic studies of the helicon wave discharge, which is one of the leading contenders for the industrial source of the future. The emphasis at the moment is to understand the mechanism of antenna coupling and the propagation and ionization characteristics of helicon waves. For low-damage semiconductor fabrication, it is sometimes desirable to have a low electron temperature and no energetic particles. Matsumoto et al. (**3**-317) have developed a 6-phase ac discharge that runs off the 60-Hz power lines. The voltage is applied to six meter-long rods inside a large tank and produces a uniform plasma of mid-$10^9$ cm$^{-3}$ density and with $T_e$'s only 0.3 eV. The extensive numerical modeling which industry supports was missing from this conference, but there were scattered theoretical treatments. Massi et al. (**1**-293), for instance made a transformer model of an rf inductive discharge at São José dos Campos, and Deutsch and Schwarz of Stuttgart made a circuit model of the sheath in an RIE (Reactive Ion Etching) discharge. Plasma sources for sputtering are widely used in industry. Ferreira et al. (**3**-297) of Brasília reported on a multidipole source for producing ion beams for sputtering, and Garamoon et al. (**3**-301) of Cairo showed measurements of a dc magnetron sputtering unit. Urai et al. (**3**-69) of Tokyo studied the electron orbits in a wire-anode ion plasma source, in which they precess around one or two straight wires in a magnetic field. Choi et al. (**3**-25), in a UK-Chile-Israel collaboration, studied the ionization processes in a transient hollow cathode discharge. Nogeira et al. (**3**-329) of Brazil were concerned with optimizing a dc methane discharge between graphite electrodes in regard to how the wall temperature affects the breakdown voltage. The discharge is used for plasma enhanced chemical vapor infiltration to produce carbon composites of importance to aerospace. These examples amply illustrate the international nature of this research field.

**Plasma polymerization.** The use of plasmas to produce strong plastic films and coatings is usually covered in chemical rather than plasma conferences, but in ICPP'94 there were several papers on plasma polymerization from Brazil. Durrant et al. (**3**-293) studied how the properties of films made from acetylene ($C_2H_2$)-Ar-$O_2$ plasmas depended on the concentrations of $O_2$ and the CH and CO precursors. Teixera et al. (**3**-353) studied CH and H formation in Ar-$C_2H_2$ and $N_2$-$C_2H_2$ plasmas excited by both dc and rf and measured the refractive index of the films produced. Da Cruz et al. (**3**-277) measured plastic films made in $SF_6$-methanol and $SF_6$-acetone discharges.

Mota et al. (**3**-325) spectroscopically analyzed the radicals in a dc-excited Ar-HMDSO (hexamethyl disiloxane) plasma, commonly used to make strong Plexiglas films.

**Miscellaneous applications.** In other applications there were too few papers to form any coherent group. Kitajima et al. (**3**-309) of Tsukuba studied how the production rate of oxide layers on Si depended on the substrate bias in an $O_2$ plasma. Vasilevskiy et al. (**3**-361) of Nizhniy Novgorod calculated the dissociation rates of metal-organic compounds in an rf He discharge used for PECVD (plasma enhanced chemical vapor deposition) of epitaxial layers. The large field of plasma source ion implantation (PSII) was represented only by a handful of papers. For instance, Mukherjee and John of India (abstract only, p. 206) examined the rarefaction wave that ensues when a high negative voltage on the substrate is turned off. Rossi et al. of Brazil (**3**-341) tacked one of the main problems in PSII--the design of the large power supply, in this case giving a 50kV, 5A, 5μs pulse at 10 Hz. Thermal plasmas--i.e., those at nearly atmosphere pressure--are less well known to the plasma community than to industry, where the use of torches, arcs, and sprays in manufacturing is widespread. Szente gave an invited review of these applications. Bruzzone et al. of Argentina (**3**-273) showed how a dense TiN coating on steel can be formed with a pulsed, Ti-cathode arc in a nitrogen discharge, provided that the object is exposed to a glow discharge first.

## 6. NOVEL APPLICATIONS

Plasma isotope separation is potentially an important application, but no papers were given on the ion cyclotron resonance method, which has been studied extensively for uranium but not for other elements of medical importance. There was, however, a paper on atomic vapor laser isotope separation (AVLIS) by Matsui (**3**-313) of Japan. Here the problem is to collect the desired ion species rapidly once it has been selectively ionized by the laser. Matsui proposed to add a magnetic field and then cyclotron accelerate the ions to the walls. Using a more classical approach to isotope separation, Simpson et al. (**3**-349) of Australia are developing a high-pressure plasma centrifuge with a cylindrical anode and an axial cathode in a magnetic field. Another type of plasma centrifuge was studied by Dallaqua et al. (**3**-281) of Brazil. Here, the cathode does not extend into the separation chamber but is separated from it by a mesh anode. A radial electric field is nonetheless produced which spin the different species in a magnetic field.

Experiments in fusion-like toroidal geometries were reported by two groups. Mukherjee and Bora (**3**-49) of India used helicon waves to create a plasma in a torus and measured the wave and plasma profiles. Armstrong et al. (**3**-153) of Norway told of a large toroidal device in Oslo which was filled, according to Schrittwieser and Armstrong (**3**-225), by an arc discharge between an internal filament and the limiter. No toroidal drifts were seen, a result that is not yet explained. In another fusion-related basic development, Idehara et al. (**3**-285, 325) reported on the development and use of high-power gyrotrons, including a new world frequency record of 50W at 830 GHz.

Besperstov et al. of Moscow (abstract only, p. 424) have found a way to make fine metal powders by exploding a continuously fed metal wire with a 6 kV capacitor bank in an argon atmosphere. Wire diameters of 0.3 mm produce 30-nm diam particles. Irie et al. (**3**-305) of Waseda Univ. in Shinjuku, Tokyo, are engaged in lightning research, of importance to electrical power companies because of the need to protect high-voltage transmission lines from lightning strikes. It is commonly thought that an electron trail produced with a laser would be an efficient way to trigger lightning strikes so that they would not occur in unexpected places. However, in experiments using a rail gun plasma, it was found that excited neutrals or negative $O_2^-$ ions are more important in initiating lightning than free electrons.

## 7. CONCLUSION

The distribution of papers in this conference reflects the global change in basic plasma research away from the traditional areas to areas to more immediate utility. A number of papers have been cited as examples; the author apologizes to those authors whose work could not be mentioned in this short review. The organization of this conference at a remote location and in conjunction with a rare display of solar plasma was a formidable and thankless task. The organizers of ICPP'94 are to be congratulated not only for accepting the challenge but also for providing a highly successful forum in which plasma scientists all over the world can show the strength and vitality of their research efforts.