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SEMI-ANNUAL STATUS REPORT

TO

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FROM

THE UNIVERSTIY OF TEXAS AT DALLAS
P.O. BOX 688
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(214) 690-2851

ON

"A RESEARCH IN SUPPORT OF NASA'S SPACE SCIENCE"

NASA Grant NGL 44-004-130
(UTD Account E1306)

For the Period

1 October 1981 - 31 March 1982

W. B. Hanson
Principal Investigator

August 1982

and the refinement of Monte Carlo procedures for modelling the distribution of neutral gas in the outer magnetosphere. In addition, the role of inductive electric fields in the acceleration of plasmas has been examined with application to the earth's magnetosphere and the sun, and a step toward a clear understanding of magnetic reconnection is emerging from quantum theory concepts applied to space plasmas.

We expect our work in these various areas to continue productively during the tenure of this grant and that, as in the past, new and innovative concepts will emerge for future research.

SMALL-SCALE IONOSPHERIC IRREGULARITIES

J. P. McClure, Cesar Valladares, B. L. Cragin and W. B. Hanson

We have conceived and developed new instruments that have proved useful in unraveling the varied plasma instability processes present in the ionosphere. We report here on two aspects of our plasma instability studies: 1) design consideration for the comb filter bank intended to extend observations down to 1 m scale without significantly increasing telemetry requirements, and; 2) the characteristics of a newly discovered instability category found uniquely in the bottomside equatorial nighttime F region within 12° or less from the dip equator.

Though our instruments have revealed new plasma processes through unprecedented sensitivity to and spatial resolution of small-amplitude, small-scale fluctuations in plasma concentration N_i and drift V_i, the full bandwidth capability of these instruments has not yet been fully exploited, partly because of the limits of available telemetry on the AE and DE spacecraft. We have designed an analog filter having wide dynamic range for use with our drift meter and N_i detector to be flown on an upcoming DOD satellite. The filter channels have logarithmic detectors to maximize their dynamic range; the linear amplifier preceding these filters is locked on a range that is optimum at a time just after the filter outputs have been telemetered, and not allowed to change until they are again telemetered. The nature of the processes being studied is to change rapidly in space, and hence in time in the satellite frame. These changes can be followed at a resolution of several tens of meters via the normal telemetry and, if the changes are not too rapid, average plasma properties at shorter scale sizes (to $\sim$1 m) will be accurately sampled by the filters, though only once every few km.

A new phenomenon consisting of km-scale "vertically" oriented alternately rising and falling sheets of plasma in the nighttime equatorial F region has been studied. We have called it BSS because of its "Bottomside Sinusoidal" signature. It appears some 6% of the time, only on the bottomside of the F region, and with an east-west scale size of 0.3- to 3-km. Sinusoidal V_i fluctuations also appear, exactly in phase with the sinusoidal N_i fluctuations such that the depletions in N_i move upward while the enhancements move downward. North-south motions likewise are sinusoidal and phased-locked to the N_i variations such that plasma moving upward flows away from the equator and vice versa, as one might expect on theoretical grounds. BSS is independent of other typical larger-scale equatorial instability signatures such as the deep plasma "bubbles" or depletions and the large-scale corrugations in F-region altitude. Any one, any two or all three of these signatures may be seen near the same location or widely separated on a given orbit. BSS is long lived. Stable patches are seen on two and even three successive orbits through a given region. The east-west dimension of BSS patches can be quite large. Sizes up to 7000 km have been seen, and the outer limit may be significantly larger because BSS has been observed from soon after sunset (7 PM) until well after sunrise (7 AM). A paper describing BSS is in the final stage of preparation.

E AND F REGION COUPLING

R.A. Heelis

The procedures developed to model the electrodynamic coupling of the E and F regions have been applied to simple diurnal tides in the E-region. The resulting F-region current distribution has been studied in relation to the E-region conductivity to determine its effectiveness in producing the post sunset enhancement in vertical ion drift observed at the dip equator.

It appears that the degree to which such an enhancement is observable depends upon the relative diurnal phase difference between the E-region conductivity distribution, the F-region neutral east-west wind, and the F-region east-west ion drift. The east-west wind produces the largest F-region field aligned currents near sunset when the time lag between the change in sign of the neutral wind and the ion drift is a maximum. These large field aligned currents must be driven across the large E-region conductivity gradient that exists at this time and the resulting enhanced electric field produces the observed drift paths.

We have successfully modelled the physics describing this problem and Figure 1 shows the vertical ion drift at the equator that is produced by the F-region field aligned currents.

Several questions remain to be answered and different situations to be modelled. We must first determine the effects of the E-region conductivity on the magnitude of the observed drift and then ascertain what contribution if any can be made to this simple picture by semi-diurnal tides. Following this study, seasonal effects in the F-region can be studied by changing the neutral wind field and the distribution of ionization. Our ultimate goal is to delineate the dominant factors producing the observed seasonal dependence in F-region drifts and then to attempt to add some degree of self-consistency between the F-region ion drifts and the distribution of ionization.

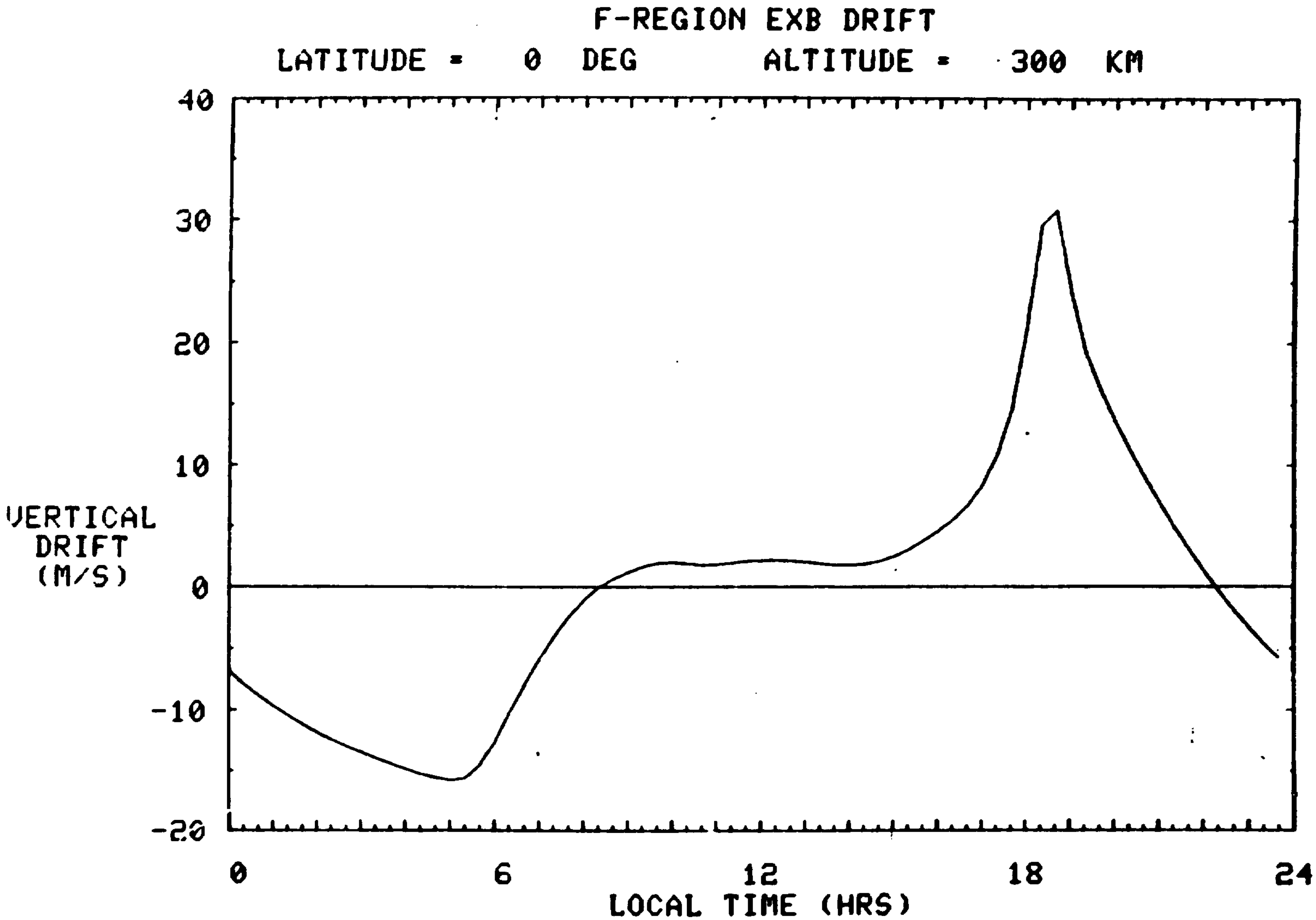
F-REGION EXB DRIFT
LATITUDE = 0 DEG ALTITUDE = 300 KM
40
30
20
10
0
-10
-20
VERTICAL
DRIFT
(M/S)
0
6
12
18
24
LOCAL TIME (HRS)

FIGURE 1

THE MEASUREMENT OF INDIVIDUAL ION FLOW VELOCITIES

R.A. Heelis

We have pursued the concept of using a repeller and compensator grid pair in the ion drift meter to minimize the effect of the H^+ repeller voltage on the heavier ion arrival angle.

The grid configuration for such a detector is shown in Figure 2 where the compensator grid will be negatively biased to provide focusing rather than defocusing in the drift space. We have performed particle trajectory calculations for such a grid arrangement to determine the ratio of repeller to compensator voltage required to minimize the distrurbance to O^+ ions. We have assumed a spacecraft velocity of 7.5 km/sec so that O^+ ions have an incident energy of 4.7 eV. Table 1 shows the repeller and compensator potentials that produce the minimum effect. It can be seen that over the repeller voltage range required to exclude H^+ ions a constant ratio of repeller to compensator potential can be used.

The detection scheme itself will utilize a relatively low frequency (200 Hz) square wave with an amplitude of about 100 mV. This will be superimposed on the DC repeller voltage to produce a modulation in only the H^+ ion current at the collector. Synchronous detection of the logarithmic ampliriers connected to each collector segment will isolate the H^+ signal and using this signal as input to a linear difference amplifier will provide the H^+ ion arrival angle in the usual way. Preliminary circuit and logic design is now underway and we expect to describe the flight operation of such a device in the next proposal period.

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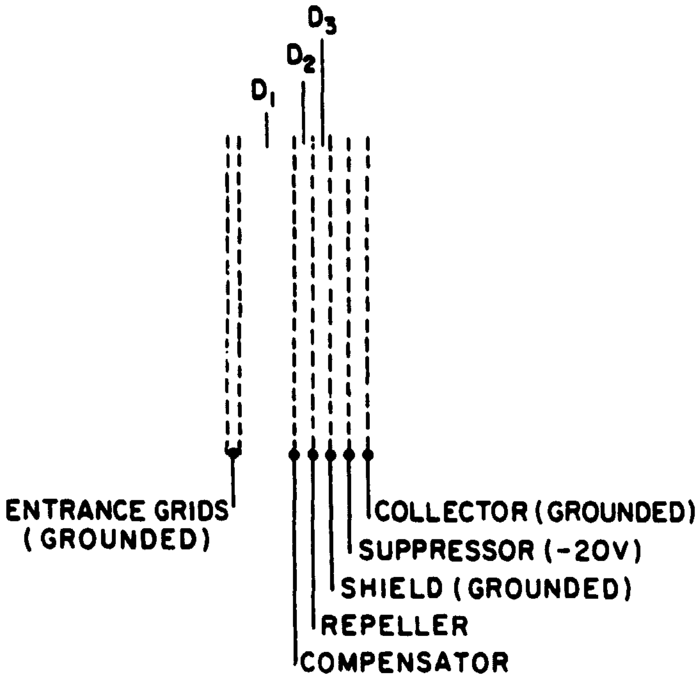

GRID	SPACING
D_1	0.28"
D_2	0.10"
D_3	0.10"

FIGURE 2

TABLE 1

Repeller Voltage	Compensator Voltage	Ratio $\frac{C}{R}$
0.2	-0.108	-0.54089
0.4	-0.222	-0.55638
0.6	-0.344	-0.57288
0.8	-0.472	-0.59050
1.0	-0.609	-0.60941
1.2	-0.756	-0.62970
1.4	-0.912	-0.65159
1.6	-1.080	-0.67528
1.8	-1.262	-0.70135
2.0	-1.458	-0.72917

PRODUCTION MECHANISM FOR BURSTS OF HIGH ENERGY PARTICLES

W.J. Heikkila

Dr. Heikkila attended the conference "Physics of the Jovian and Saturnian Magnetosphere" at the Applied Physics Laboratory, Johns Hopkins University, October 22-24, 1981, and presented a paper entitled "Natural Accelerator for Cosmic Plasmas." In it he described how a magnetized plasma can accelerate particles to very high energies by a two step process. First, linear acceleration occurs along a newly-formed magnetic neutral line by an induced electric field; this induction field is temporarily enhanced by the plasma along the neutral line, because of the different topologies of rotational and irrotational fields. Some particles are able to gain very high values of the first adiabatic invariant at low values of the magnetic field strength. In fact, this is simply a discharge of the neutral line. Second, betatron acceleration by the non-conservative electric field can increase the energy orders of magnitude; this is just magnetic compression. Both electrons and ions can be energized to millions of electron volts by this two step process in a matter of seconds. This mechanism is effective in the earth's magnetotail at substorm onset, in other magnetospheres, and in solar flares.

The past work was done assuming a uniform current density in the magnetotail. However, we have postulated that the current is filamentary in nature, not uniform; such a filament is connected to an auroral arc. This filamentary nature of the cross-tail current is also important for producing an induction electric field. At the present time work has been undertaken with such a filament, at first with just an electrostatic field in the magnetotail to explain quiescent auroral arcs. After that, we intend to look at induction effects, and the creation of new neutral lines, and the two stage acceleration process again.

ION-NEUTRAL INTERACTIONS IN THE TERRESTRIAL MAGNETOSPHERE

R.R. Hodges, R.P. Rohrbaugh and B.A. Tinsley

Charge exchange of the neutral hydrogen and oxygen coronas of the earth with magnetospheric ions affects the composition and velocity distributions of both ions and neutrals. Because ion kinetic energies generally exceed those of neutrals, charge exchange results in a net heat transfer from ions to neutrals. This provides the 'hot' hydrogen of the exosphere, and most of the escaping and orbiting components. Charge exchange is also thought to have significant effects on ion pitch angle distributions.

Analytic methods of analysis of the effects of exospheric collisional processes have been of little value because of the nonequilibrium and spatially inhomogeneous natures of virtually all exospheric phonomena. What has recently proved to be fruitful i. the adaptation of Monte Carlo exospheric simulation methods that were developed earlier at UTD in studies of the behavior of volatiles on the moon and Mercury. The feasibility of Monte Carlo simulation of the terrestrial exosphere has been demonstrated in an investigation of the influence of the charge exchange reaction of neutral hydrogen and ionospheric protons on the origin and morphology of 'hot' hydrogen (Hodges, Rohrbaugh, and Tinsley, 1981).

We have formulated a new model of the ion temperature composition and concentration within the plasmasphere, which has an improved ion temperature variation in the critical region for charge exchange, 500 km to 2000 km altitude, and a realistic solar cycle variation, and we are using it to provide improved production rates for both 'hot' hydrogen and 'hot' oxygen. We have included in the Monte Carlo calculations neutral-neutral collisions, especially H_{hot} + H and O_{hot} + H and high altitude H + H collisions which affect the satellite population. The collisional advection of hydrogen atoms below the exobase by thermosphere winds is included. Models of the terrestrial hydrogen exosphere are being computed for a range of solar activities, including maximum and minimum conditions. In addition, we are investigating Lyman α optical depth in the exosphere and its influence on the perturbation of atom trajectories, particularly over the night hemisphere at distances less than 2 earth radii from the extension of the earth-sun axis.

Reference:

Hodges, R.R., R.P. Rohrbaugh, and B.A. Tinsley, "The effect of the charge exchange source on the velocity and 'temperature' distributions and their anisotropies in the earth's exosphere," J. Geophys. Res., 86, 6917, 1981.

THERMAL ELECTRON BIRKELAND CURRENTS

D. M. Klumpar

During this funding period we have continued our review of measurement techniques for thermal electron drift motion. At this time the commitment of time and funds to the design and breadboard construction of possible detectors does not seem worthwhile. We have therefore concentrated our efforts on a rigorous understanding and formulation of the applicable physics that will be required to interpret the signals from the resonance technique described in our proposal.

The main thrust of our investigations this year has been in the interpretation of satellite data to determine the location and conditions under which thermal electrons might be expected to carry a substantial fraction of the Birkeland currents. The ISIS 2 satellite provides an adequate pitch angle distribution of electrons with energies greater than about 5 eV and in addition is able to identify regions of field-aligned currents from their magnetic perturbations. These measurements have enabled us to identify the equatorward edge of the auroral zone in the 18:00 to 24:00 hrs local time sector as a region where we suspect that very low energy electrons are contributing to the total Birkeland current.

In addition, it appears that localized electric fields near the poleward edge of the auroral zone in the 24:00 hrs to 06:00 hrs LT sector may accelerate the thermal electrons to 5 or 10 eV when their flux can account for a significant amount of the current. The physical conditions under which such electron acceleration can exist must be carefully examined and correlations with local thermal electron number density and temperature must be gathered to fully describe the situation.

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STRATOSPHERIC ION COMPOSITION

John H. Hoffman and A. J. Cunningham

The work being reported here concerns laboratory developmental studies of measurement techniques for sampling large cluster ions from a stratospheric pressure level (∿1torr) gas. This is in preparation for a proposed series of stratospheric balloon flights whose primary objective is to identify the positive and negative cluster ions in the altitude range 20 to 40 km and to measure their concentrations and variabilities. Although this goal is similar to that of the studies by the groups of Arnold[1] and Arijs[2], who have provided the first *in situ* measurements of the ion composition in the stratosphere, there are several important differences in the work planned here. Use of magnetic sector mass analyzers rather than quadrupole mass filters for the ion composition measurements will fill the recognized need for improvements in mass resolution (especially at masses exceeding 200 amu) and extension of the mass range to be mapped in future stratospheric ion composition studies. Both these requirements can be optimally achieved using the magnetic sector geometry.

Recent pioneering studies by Arnold and co-workers[1] and Arijs et al.[2] revealed the expected presence of hydrated cluster ions in the stratosphere and in addition a myriad of new families of ions having various trace atmospheric constituents attached to different ion cores. Of special interest was the observations of large cluster ions containing H_2SO_4, HN_3, CN and CH_3CN. These pollutants are present at such low concentrations that unambiguous quantitative detection in the stratosphere by other (optical and direct neutral mass spectrometric) detection methods is very difficult. Indeed H_2SO_4 and CH_3CN had eluded detection prior to the ion mass spectrometer measurements. This success suggests that in situ ion composition measurements might now be further developed for the quantitative detection of trace gases in general (including pollutants) in the stratosphere. Such information can be obtained from relative count rates (as measured by a mass spectrometer) provided the underlying ion chemistry, associated kinetics and appropriate thermodynamic data (obtained from laboratory measurements) is available. Estimated detection limits as low as 1 ion/cm^3 have been suggested.[1,2]

If the analysis procedures can be developed, a wealth of new data concerning the identity, concentrations and morphology of major and minor trace gases could be anticipated. Such information would have immediate environmental relevance because of continuing interest in an improved understanding of the effects of pollutants in modifying the earth's radiation budget, in destroying the life sustaining ozone layer and also in evaluating suggested formal links between ions in the stratosphere and weather and climate.[3] Particular interest in H_2SO_4 arises because the stratospheric aerosol (Junge) layer consists of a 75% sulfuric acid 25% water vapor mixture and because sulfuric acid is thought to be a major nucleating agent in the atmosphere.[3] Information of the above type will be of critical importance in ongoing efforts to develop tractable kinetic models of the neutral and ion chemistry of the stratosphere. Such modelling efforts may ultimately prove useful in attempts to describe the long and short term effects of increased pollution on a global scale.

An instrument package suitable for in situ sampling and measurement of positively and negatively charged species in the stratosphere has been identified. The design selected is a scaled version of the analyzers used on the Pioneer Venus multi-probe mission in 1978 to measure the ion composition of the lower atmosphere of that planet.[4] The analyzer has three output channels (see Table 1 for parameter summary) that cover the mass ranges 12-48, 40-160 and 150-600 amu with resolutions, (10% valley between adjacent peaks of equal amplitude) of 60, 150 and 500 respectively on the low, mid and high mass ranges. Another important characteristic of the magnetic analyzer is illustrated graphically in the bottom of Figure 1. Shown is a sample spectrum obtained from the low mass channel of the Pioneer Venus instrument following electron impact of a gas sample containing the rare gases Kr and Xe. Intended to cover only the 1-16 amu mass range, this graph shows the result of decreasing the ion acceleration voltage exponentially with time so that the scale of the abscissa is logarithmic in mass. On this type of plot, peak width is approximately independent of mass, resulting in increasing overlap of adjacent peaks. The spectrum clearly shows the presence of krypton (80-86 amu) and xenon (128-136 amu) at nearly 10 times the mass for which the channel was designed to operate, but with no identification of isotopic abundances. At the top of Figure 1 is the spectrum of Xe^+ obtained simultaneously by the high mass channel of the same instrument. For the proposed stratospheric balloon flights the mass analyzers will be capable of resolving 500 amu peaks on their high mass/resolution channels, and by analogy with the bottom graph of Figure 1, they will provide more poorly resolved spectra to about 5000 amu. This ability to disperse very high masses (albeit with poorer resolution) is unique to the magnetic sector geometry and represents a major advance over that attainable using quadrupole analyzers whose resolution rapidly deteriorates at higher mass.

Following the selection of an analyzer design, laboratory studies were initiated to gain experience in the preparation and non-destructive sampling of very large cluster ion species and the transport of such ions from ambient stratospheric pressures to the high vacuum conditions of the analyzer itself.[5] In this context, it is important to note that in a magnetic sector analyzer the applied accelerating electric field is inversely proportional to mass. This situation should prove advantageous in the transport of the larger ion species through the mass analyzer with a minimum of breakup. In comparison, applied fields are directly proportional to the ion mass in quadrupole analyzers and Arnold et al.[1] have reported problems in sampling of weakly bound cluster ions. For the purpose of producing large ion clusters in the laboratory a cooled ion source has been developed.

One version of the ion source that has been tested consists of a set of concentric rings between which a high voltage (>1000V) is applied that causes a glow discharge to occur in the gas in the chamber in which it is mounted. The pressure in this chamber is typically held between 1 and 5 torr. It is a flow through system pumped by a rotary fore pump. Ions are extracted from this chamber through a set of two slits in series that define a differentially pumped region (an oil diffusion pump maintains a pressure of the order of 10^{-4} torr between the slits). Beyond the second slit is the magnetic sector field mass analyzer in a large chamber pumped by a large turbo-molecular pump. Pressure in this chamber is maintained in the 10^{-7} to 10^{-6} torr range. The glow discharge chamber, which is internal to the intermediate pressure chamber, is cooled by liquid nitrogen.

The system has been debugged and is now operational. Tests have been run using xenon, krypton, water vapor in air, sulfur hexafluoride and carbon dioxide. Figure 2 is a spectrum of SF_6 from 30 to 363 amu. Some of the peaks are labeled in amu. The numbers above the peaks refer to the approximate ion accelerating voltage at the time the peak was read. The vertical scale is a 6 decade log scale. This spectrum was taken with a wide entrance slit on the mass spectrometer. Subsequent work will involve optimizing the slit dimensions and differential pumping system. However, this source design is not ideal for producing large cluster ions since the ions experience the internally applied breakdown fields during their residence time in the source. Such fields cause dissociation of large cluster ions.

Another design presently being evaluated to overcome the problem described above employs an externally generated electron beam which is directed into the source itself through a small (side mounted) slit of similar dimensions to the exit slit of the source. The electron beam impacting the source gas produces primary ions which cluster but now without the complicating presence of internal fields. The beam can be used in either the pulsed or continuous mode. A prototype design is presently being tested.

TABLE 1

INSTRUMENT PARAMETER SUMMARY

INSTRUMENT:	Magnetic sector field mass spectrometer with differentially cryo-pumped entrance system.
MEASURED PARAMETERS:	Positive and negative ion concentrations (one mass analyzer for each)
MASS RANGE:	Three output channels from each analyzer.
	Low range: 12-48 amu
	Mid range: 40-160 amu
	High range: 150-600 amu, extended to 5000 amu
RESOLUTION: (10% valley)	Low range: 60
	Mid range: 150
	High range: 500
	(unit mass identification to 600 amu)
SENSITIVITY:	1 ion/cm^3 for 1 sec accumulation period.
POWER:	9 w
WEIGHT:	125 kg
SIZE:	80 cm dia (hermetically sealed spherical gondola)

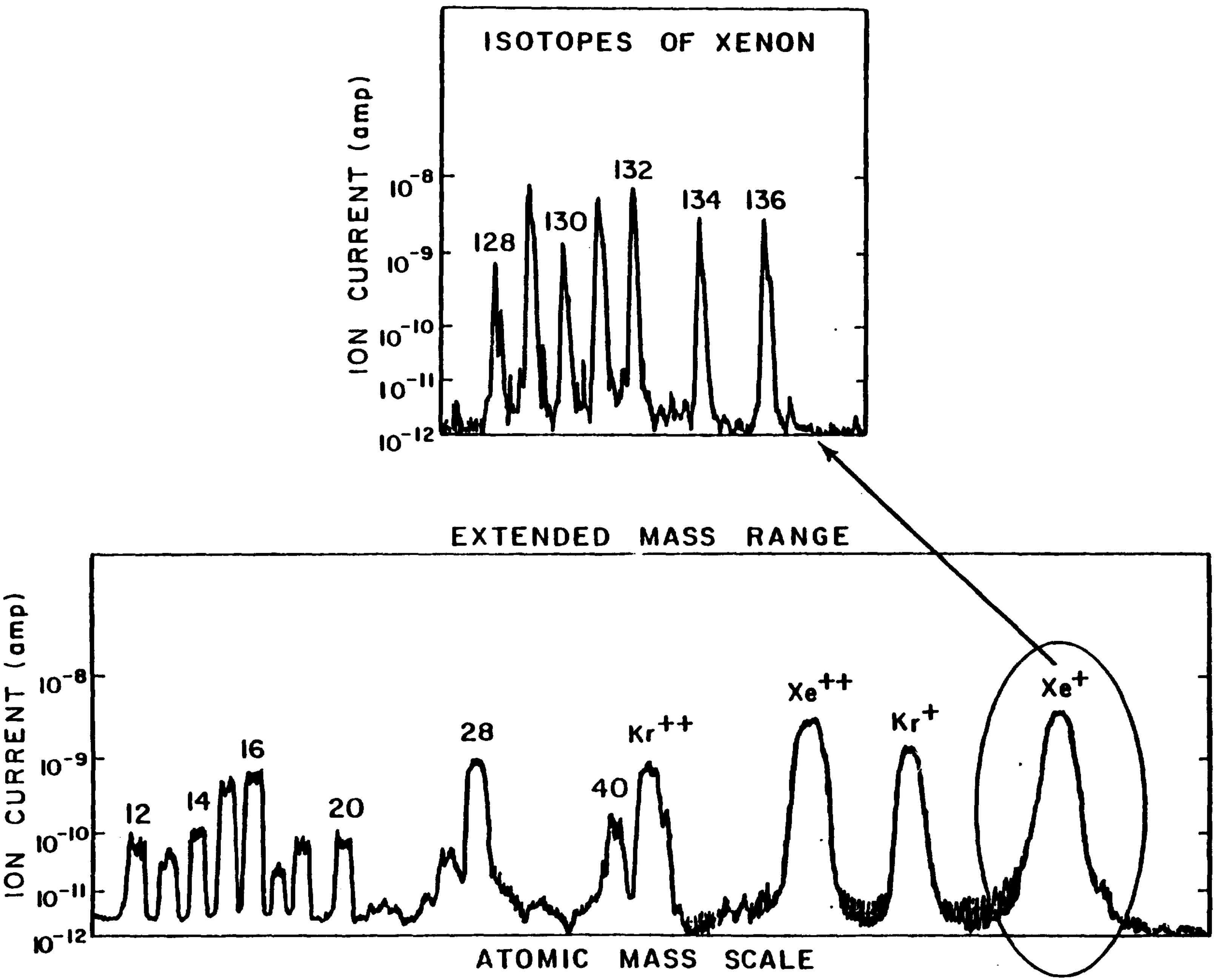
ISOTOPES OF XENON
ION CURRENT (amp)
10^-8
10^-9
10^-10
10^-11
10^-12
128
130
132
134
136
EXTENDED MASS RANGE
ION CURRENT (amp)
10^-8
10^-9
10^-10
10^-11
10^-12
12
14
16
20
28
40
Kr++
Xe++
Kr+
Xe+
ATOMIC MASS SCALE

Figure 1

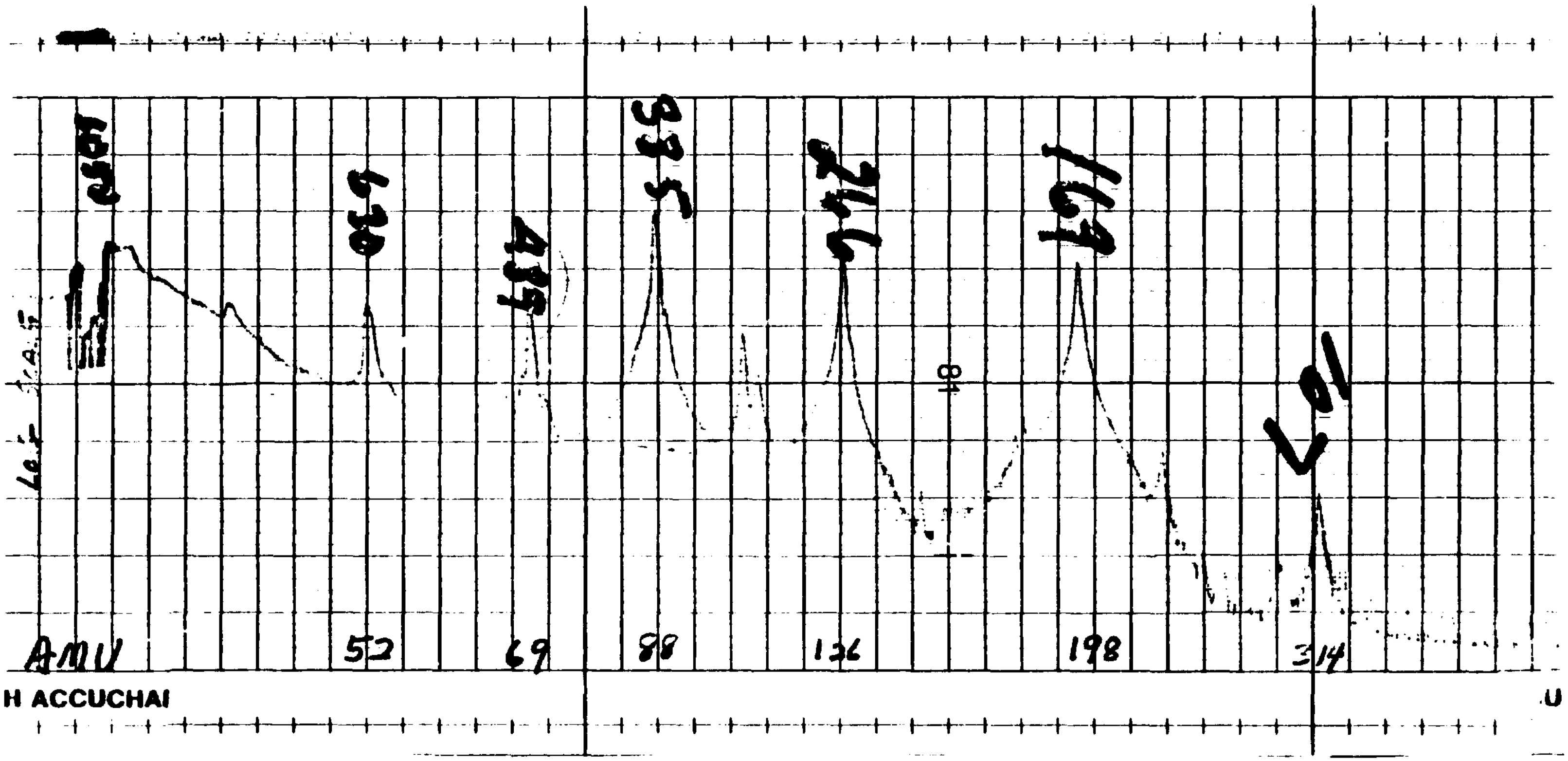

Figure 2

REFERENCES

1. See following recent papers and references cited therein:

Arnold, F. and R. Fabian, First measurements of gas phase sulfuric acid in the stratosphere. Nature 283, 55-57 (1980).

Arnold, F., R. Fabian, G. Henschen and W. Joos, Stratospheric trace gas analysis from ions: H_2O and HNO_3. Planet. Space Sci. 28, 681-685 (1980).

Arnold, F., R. Fabian and W. Joos, Measurements of the height variation of sulfuric acid vapor concentrations in the stratosphere. Geophys. Res. Lett. in press, (1981).

Arnold, F., G. Henschen and E. E. Ferguson, Mass spectrometric measurements of fractional ion abundances in the stratosphere I: Positive ions. Planet. Space Sci. 29, 185-93 (1981).

Arnold, F., R. Fabian, E. E. Ferguson and W. Joos, Mass spectrometric measurements of fractional ion abundances in the stratosphere II: Negative ions. Planet. Space Sci. 29, 195-203 (1981).

2. See following recent papers and references cited therein:

Arijs, E., J. Ingels and D. Nevejans, Mass spectrometric measurements of the positive ion composition of the stratosphere, Nature 271, 642-644 (1978).

Arijs, E., D. Nevejans and J. Ingels, Unambiguous mass determination of major stratospheric positive ions, Nature 288, 684-686 (1980).

Arijs, E., D. Nevejans, P. Frederick and J. Ingels, Negative ion composition measurements in the stratosphere. Geophys. Res. Lett., in press, (1981).

3. See following recent papers and references cited therein:

Arnold, F., Multi-ion complexes in the stratosphere-implications for trace gases and aerosol, Nature 284, 610-611 (1980).

Dickinson, R.E., Bull. Am. Met. Soc. 56, 1240 (1975).

Turco, R.P., R. C. Whitten, O. B. Toon, J. B. Pollack and P. Hamill, OCS, stratospheric aerosols and climate, Nature 283, 283 (1980).

4. See following recent papers and references cited therein:

Hoffman, J. H., R. R. Hodges, Jr., M. B. McElroy, T. M. Donahue and M. Kolpin, Composition and structure of the Venus atmosphere: results from Pioneer Venus, Science 205, 49-52 (1979).

Hoffman, J. H., R. R. Hodges, Jr., W. W. Wright, V. A. Blevins, K. D. Duerksen and L. D. Brooks, Pioneer Venus Sounder Probe Neutral Mass Spectrometer, IEEE Trans. Geosci. and Remote Sensing GE-18, 80 (1980).

Hoffman, J. H., R. R. Hodges, Jr., T. M. Donahue and M. B. McElroy, Composition of the Venus lower atmosphere from the Pioneer Venus Mass Spectrometer, J. Geophys. Res. 85, (Sept. 1980).

5. See following papers and references cited therein:

Cunningham, A. J., J. D. Payzant and P. Kebarle, A kinetic study of the proton hydrate $H^+(H_2O)$ equilibria in the gas phase, J. Amer. Chem. Soc. 94, 7627-7632 (1972).

Payzant, J. D., A. J. Cunningham and P. Kebarle, Kinetics and rate constants of reactions leading to the hydration of NO_2^- and NO_3^- in gaseous oxygen, argon and helium containing traces of water, Can. J. Chem. 50, 2230-2235 (1972).

Payzant, J. D., A. J. Cunningham and P. Kebarle, Gas phase solvation of the ammonium ion by NH_3 and H_2O and stabilities of mixed clusters $NH_4^+(NH_3)_n(H_2O)_w$, Can. J. Chem. 51, 3242-3249 (1973).

Quantum Versus Classical Concepts in Space Plasma Physics

B. L. Cragin

This investigation concerns itself with the interpretation of magnetic reconnection (or merging) in quantum-mechanical terms. It is well known that a number of essentially classical plasma physics phenomena can be clearly and simply elucidated in terms of quantum-mechanical concepts. Even though the introduction of such ideas in a classical context is in principle unnecessary, one can nevertheless gain useful insight in this way. We believe that the same may be true for magnetic reconnection.

In our most recent proposal a description was given of magnetic reconnection in the vacuum limit, and of the role played in this limit by quantum fluctuations of the electromagnetic field in producing a region analogous to the diffusion zone of ordinary reconnection theory.

It was suggested at that time, mainly on the strength of order-of-magnitude type arguments, that resistive magnetic reconnection in plasmas (at least insofar as diffusion zone phenomena are concerned) might be treated using essentially the same type of field-theoretic approach, but taking electrostatic field contributions and thermal fluctuations into account, and noting that the additional fluctuations of purely quantum origin play a negligible role in this case. A major research accomplishment during this report period has been the completion of a fairly rigorous demonstration that the average "frictional" force due to electron-ion collisions (and hence, by inference, also the plasma resistivity and magnetic diffusivity) can in fact be derived in this way. The fluctuation-dissipation theorem of non-equilibrium statistical mechanics forms the cornerstone of this approach. In a factorization approximation, results completely consistent with conventional plasma transport theory were obtained. This positive result tends to support the conclusion that these seemingly very different phenomena really are quite closely related conceptually, and we believe that we thus have at least the beginnings of a quantum description of magnetic reconnection.

SOLAR WIND MAGNETOSPHERE INTERACTION

W.J. Heikkila

A paper was presented at the IAGA meeting in Edinburg, Scotland (August 3-15, 1981) on this topic, and also at the meeting at Yosemite, California (January 25-29, 1982) on "Origin of Plasmas and Electric Fields in the Magnetosphere." A paper, based on these qualitative ideas, is now being written for publication.

An important part of the interaction is the question of entry of solar wind plasma (or magnetosheath plasma) through the magnetopause current into the boundary layer. A new process of impulsive entry has been published by Dr. Heikkila (Geophysical Research Letters, 9, 159, 1982). It is assumed that a localized plasma cloud of magnetosheath plasma with some excess momentum distorts the surface of the magnetopause, and its associated currents, inducing an electric field that can be of the order of 1 mV/m. This induction electric field by itself is just what is needed so that the plasma can follow the moving magnetopause. A normal component of the magnetic field B_n through the magnetopause will permit a small field-aligned polarization current; this current will deliver charge that will create an electrostatic field. The normal component of the total electric field will be reduced (perhaps to zero) while the tangential component will be enhanced. This enhancement will allow the cloud to continue moving toward the moving magnetopause. At the same time the plasma particles will be slightly energized, and being propelled by the mirror force $-\mu\nabla B$ they will become more field aligned as they go through the magnetopause. Energy for these events comes from the excess momentum via the induction electric field. Once inside the moving magnetopause, the cloud can go across field lines (either open or closed) until it loses its excess momentum. A cross-sectional slice of the plasma cloud (at the inner edge of the magnetopause current) acts as a generator; the whole process can be regarded as an electric circuit, with a generator preceding the load, the trailing portion of the current. Losses of particles, momentum, and energy will occur; the mechanism described is one possible form of "viscous interaction" between the shocked solar wind and the magnetosphere. The total amount of power going into the plasma is likely to be much less than 5×10^{11} watts, and may even be negative, indicating the futility of searching for dissipation of this magnitude. In a further paper ISEE electric field measurements were analyzed that gave good support for this model. Now we are beginning work on the motion of individual charged particles with the topology of magnetic and electric fields that was assumed in the above papers to find the plasma response, in particular the effect of the $\underline{J} \times \underline{B}$ forces, and the energy relationships.

ZOOM IMAGING SPECTROMETER

B.A. Tinsley

The concpet of using a zoom lens in conjunction with an annular aperture to change the angle of incidence of light transmitted by a Aabry Perot Etalon, or an interference filter, and thereby provide a spectral scan, has been tested and shown feasible. A zoom lens with 3:1 focal ratio designed for 35mm photography and a variable diaphragm have been motorized with stepping motors, and controlled by a borrowed Apple II computer through interface boards which we have constructed. We have tested the system with a filter of nominal 3 Å bandwidth and have used it to obtain a spectrum over a range of about 30 Å in the vicinity of 7774 Å.

The system works well and we were able to make measurements on nightglow hydroxyl emission and the OI 7774 emission due to radiative recombination in the mid latitude F regions, with an instrument that was stable, light and easily directed to various sky directions, and which provided a spectrum with high resolution and high sensitivity over a much wider spectral range than is feasible with a tilting filter of comparable size and bandwidth.

We are continuing with tests to explore the system's full potential, and have installed a better photomultiplier cooling system, which will allow use of a higher resolution but lower throughput Fabry Perot Etalon, and observations of weaker sources.

We propose to work on the design of a larger unit with a mosaic of several interference filters and/or a large Fabry Perot in front of the objective, and to design a larger but optically simpler zoom or varifocal lens with about a 10:1 zoom ratio to allow a larger scanning range.