100 TeV. The helium spectrum is consistent with a single-power law in the energy range from 2 TeV/n to 200 TeV/n. Other nuclei up to Fe indicated harder spectral indices compared with those of protons and helium. The particle composition at around 500 TeV is 16 +- 5%: 29 +- 5%: 35 +- 5%: 9 +- 3%:11 +- 4%, for the abundance of p : He : C ~ O : Ne ~ S : Z > 17.

A Graduate Research Assistant (Mr. Surasak Phengchamnan) was supported under the UAH portion of Cosmic Ray during the time period February 1999 - February 2000. Mr. Phengchamnan's research effort was directed by Dr. Geoff Pendleton. The Monte Carlo simulation of the Advance Cosmic-Ray Composition Experiment for the Space Station (ACCESS) was used to study its response characteristics. The main objective of ACCESS is to measure high energy cosmic rays. The simulation results involved proton interactions at a very high energy. Response functions for ACCESS were generated in the 100 GEV to 3TEV energy range for protons. Nonlinear models were fit to the lateral dispersion of the energy deposition in the ACCESS detector planes for prototype event characterization and total event energy estimation. Energy resolution estimates were made using several different combinations of the model parameters fitted to events.

The USRA activities are included in a separate report which is submitted as a sub-contract report.

SPACE PLASMA PHYSICS

Dr. James L. Horwitz and R. Hugh Comfort's studies with the high altitude TIDE data have been progressing well. We concluded a study on the relationship of polar cap ion properties observed by TIDE near apogee with solar wind and IMF conditions. We found that in general H+ did not correlate as well as O+ with solar wind and IMF parameters. O+ density correlated best with the solar wind dynamic pressure, solar wind speed, E_{sw}, $V_{sw}B_{IMF}$, and Kp. At lower solar wind speeds, O+ density decreased with increasing latitude, but this trend was not observed at higher solar wind speeds. By comparing these results with results from other studies of O+ in different parts of the magnetosphere, we concluded that O+ ions often leave the ionosphere near the foot point of the cusp/cleft region, pass through the high-altitude polar cap lobes, and eventually arrive in the plasma sheet. We found that H+ outflows are a persistent feature of the polar cap and are not as dependent on the geophysical conditions; even classical polar wind models show H+ ions readily escaping owing to their low mass. Minor correlations with solar wind drivers were found; specifically, H+ density correlated best with IMF By, $V_{sw}B_{IMF}$, and E_{sw}. These results were presented to the Spring AGU Meeting [*Elliott et al.*, 2000a]; and a paper on this investigation has been accepted for publication in the *Journal of Geophysical Research* [*Elliott et al.*, 2000b].

Currently we are carrying out a detailed examination of observations on April 19, 1996 when the solar wind velocity was high and Alfvén waves were present in the solar wind. We have found similar large scale features in the solar wind velocity, IMF Bx, polar cap ion outflow energy of both O+ and H+, polar cap magnetic field fluctuations, and electrons precipitating in the polar cap. The high activity and the electron spectrum suggest that a 'polar squall' formed. The large amounts of O+, and the linear relationships found between polar cap data and the solar wind data mentioned above all lead us to conclude that the solar wind is driving a parallel electric field on the order of tens of volts in the polar cap, which in turn drives the polar ion outflows. Preliminary results were presented to the Huntsville 2000 Workshop (Elliott et al., 2000c). A

draft paper on this study has been prepared and is undergoing revision for publication in either Geophysical Research Letters *or the* Journal of Geophysical Research *[*Elliott et al., *2001].*

Laboratory studies of dusty plasmas have been very active. Catherine Venturini completed her MS investigation with an electron beam source (Venturini, 2000) and graduated. Some of her final results and new directions were presented to the Spring Meeting of the American Geophysical Union in Washington, DC (Spann et al., 2000). An undergraduate, (Jared Pratico) has been helping to incorporate a UV source for photoelectron production to simulate the effects of possible radiation environments on dusty plasmas. This will be a senior research project for him.

Dr. G. Germany's research focused on two space science missions, Polar Ultraviolet Imager (UVI) and ATLAS-1 Imaging Spectroscopic Observatory (ISO), and support of community activities.

UVI research included development of neural network techniques for automated identification of auroral features. Using these techniques allows determination of auroral boundaries at high temporal resolution for extended periods. *Germany et al.* [1998a] used these techniques to survey substorms as a function of time, local time, and IMF orientation. These techniques were also used to examine the initial auroral response to the January 10, 1997 CME event and resultant magnetic storm [*Germany et al.,* 1998d]. They found that the behavior of the auroral boundaries was complex but systematic. The auroral morphology showed a clear growth phase followed by expansive substorm onset, all of which were well correlated with IMF orientation.

Additional studies were performed in conjunction with other members of the UVI science team to examine the relationship between polar cap size and energy deposition [*Brittnacher et al.*, 1998b; c; e; f], further examination of the January 10, 1997 CME event [*Spann et al.,* 1998c and *Elsen et al.,* 1998b], and documention of a little known auroral feature - the midnight gap [*Chua et al.,* 1998 a;b], and comparison with ground-based and in situ observations [*Germany et al.*, 1997; 1998; *Doe et al.,* 1997; *Lummerzheim et al.,* 1997]

Comparisons of ionospheric ion outflows with UVI perigee images was presented by *Hirahara et al.,* [1998] and in work by Adam Stevenson presented at the Sixth Huntsville Modeling Workshop and to be presented at the Fall AGU meeting.

Comparison of derived energy parameters from UVI images with in situ observations was given by *Germany et al.* [1998b] and a general overview of UVI observations and related science was given by *Germany et al.* [1997; 1998c].

This period also saw the initiation of a series of studies intended to use UVI images as remote sensing aeronomic tools, particularly thermospheric composition. This work includes assessing the sensitivity of derived parameters on UVI image quality and model assumptions. This represents the most comprehensive use to date of the photometric content of the UVI images, as opposed to merely morphological content. This study focuses on detailed comparisons between modeled and observed airglow over a range of geophysical and instrumental conditions.

ISPAE investigators have collaborated in multiple auroral investigations using image data from the Ultraviolet Imager (UVI). A significant effort focused on using UVI images with monitors of solar wind parameters to investigate the auroral response to impulsive solar wind changes [Brittnacher et al., 1999a; Spann et al., 1999a; c] and to CME events [*Chua et al.*, 1999a; b; *Craven et al.*, 1999]. In a representative study, *Spann et al.* [1999c] studied the correlation between electron precipitation/auroral brightening and enhanced solar wind pressure and velocity measured by the WIND spacecraft. They were able to demonstrate a positive correlation between the amount of energy deposited in the dayside ionosphere and the magnitude of the solar wind pressure enhancement.

UVI images were also used to study auroral morphology [*Brittnacher et al.*, 1999b; c; *Fillingim et al.*, 1999]. *Brittnacher et al.* [1999b] studied the area of the polar cap as a function of local time and substorm phase determined from UVI images. They concluded that the polar cap boundary is strongly influenced by oval thinning, fading of polar cap structures, poleward expansion with substorm, and general fading of aurora. These effects dominate over equatorward boundary motion, traditionally used as a storm growth indicator. Furthermore, these processes occur independent of IMF Bz, which leads to the caveat that relating polar cap area to stored magnetic flux may not be as straightforward as previously assumed. In another study, *Brittnacher et al.* [1999c] studied poleward moving auroral forms, arcs at high latitude that move poleward from the nominal dayside oval. UVI observations were used to develop the large-scale features of this dayside phenomenon, including size and evolution. This marked the first time the large-scale picture of these forms had been studied.

Other studies focused on remote sensing techniques [*Germany et al.*, 1999b; *Spann et al.*, 1999b]. *Germany et al.* [1999b] performed a sensitivity study of extracted auroral energy parameters to choice of model cross sections and demonstrated that this potentially large source of error was actually restricted to less than 30%. This work has been accepted for publication in the Journal of Geophysical Research and is currently in press.

UVI images were also used in aeronomic studies of airglow [*Germany et al.*, 1999a] and ionospheric density and temperature variations [*Richards et al.*, 1999]. The paper by Richards et al. is primarily concerned with causes of large density and temperature enhancements that are often observed during magnetically quiet periods on winter nights at mid-latitudes in the North American sector. They found that the main aspects of nighttime density variation at Millstone Hill are well-modeled but there is substantial discrepancy between modeled and measured O+ flux at 400 km. The cause of an observed temperature collapse after midnight remains unexplained but the authors have demonstrated that there is no need to invoke flux tube compression by convection electric fields as suggested by other researchers. Rather, it is the thermal behavior of the plasmasphere that plays a key role in nighttime density variations.

In a final example of UVI collaborations, ion outflows as measured by the TIDE instrument on POLAR were correlated with the locations of auroral arcs as seen by UVI [*Stevenson et al.*, 2001; 1999a; b; *Wilson et al.*, 2001].

Dr. Shedon's three years at UAH have been particularly productive in starting experimental programs, as well as in continuing the data analysis begun before Dr. Sheldon's start at UAH. Several experimental programs that were initiated here at UAH are:

The UAH Spinning Terrella Accelerator - With support from the UAH Minigrant program, a small laboratory "table-top" experiment demonstrating the existence of space charge in strongly inhomogeneous magnetic fields, such as exist around the Earth's magnetosphere and at the magnetospheres of other planets and stars has
been set up. We have evidence for strong parallel (to B-field) electric fields that act as a linear accelerator for 10's of keV both in the lab and at Earth, or up to MeV energies at stars. This has resulted in two publications and a technical report.

Several other serendipitous discoveries have been made with this experiment, including the possibility of measuring quadrupolar trapping and acceleration, and dusty plasma sails. These discoveries have generated proposals that are presently pending.

The TOF Lab - With support from MSFC, we have designed a novel mass spectrometer that improves on the mass resolution of previous time-of-flight (TOF) space spectrometers by 10-100 fold. This revolutionary design requires the development of a unique test chamber, for which we have begun the implementation of a TOF test facility. This facility includes a fully computerized vacuum pumpdown and ion beam control, providing state-of-the-art capability for the design and calibration of the most sophisticated space hardware. Though hampered by several moves, the laboratory has been making steady progress toward becoming operational, and we have a proposal pending for the future development of this instrument for space applications.

The Computer GUI interfaces - With the advent of the Internet, much modeling work can be made more available to the scientific community through interactive internet GUI (Graphical User Interface). Several tools that I have developed over the years, including UBK particle tracing and IDL survey plots of satellite data, have had new Internet GUI interfaces added. The web sites are: ttp://cspar181.uah.edu/CAMMICE; http://cspar181.uah.edu/UBK/index5.html where the first is a relatively simple Javascript implemented data browser, and the second a much more ambitious, Perl-script interactive VRML data display still under construction.

Much of the data analysis work performed by Dr. Sheldon was started elsewhere, but continued here at UAH with new funding, so in one sense, this is work that was enhanced and made possible with this grant. LAR data analysis has resulted in several publications. Numerous published abstracts from talks are also a result of the data analysis, a few are cited in the publications, presentations list.

This grant has also enabled Dr. Robert Sheldon to teach classes at UAH and introduce prospective students to the career of physics or space physics. Much work was done to make the course materials available on the web, with distance learning. Courses he has taught were: Introductory Physics with Calculus: 111, 112, and 113; Introductory Astronomy: 106; Electronics: 337; Physics, Philosophy & Fundamentalism: H399

This grant has enabled Dr. Robert Sheldon to attend several important conferences in Dr. Sheldon's field, as can be seen from the list of abstracts above, including: Spring Meeting of the American Geophysical Union (AGU); Fall Meeting of AGU; Chapman Conference on Space Weather; Yellowstone Conference on Transport in the Magnetosphere

And finally, this grant has enabled Dr. R. Sheldon to host the bi-annual Huntsville Workshop series, Huntsville 2000 (http://science.nasa.gov/workshop7) at attractive Callaway Gardens, Georgia, where over 85 scientists came together to discuss the new results from Imaging satellites.

One activity focused on the restoration of an older, shuttle-based data set from the ATLAS-1 Imaging Spectrometric Observatory (ISO). That data set has been successfully restored from older computer platforms and transferred to new hardware as well as being reformatted in a more accessible format. A searchable database describing the contents of the data set has been extended to allow, for the first time, searching for data based on location and spectral content of the data. Newly developed software allows viewing of the spectral and instrument meta-data. This data set is available to the scientific community from an online web site that allows data searching, data requests, and software downloads

Dr. Germany served as co-Convener, along with P. Craven (NASA/MSFC), of the Sixth Huntsville Modeling Workshop held at Lake Guntersville Lodge October 26-30. Ninety-five scientists from the US, Japan, and Europe attended a weeklong series of sessions devoted to imaging of geospace via remote sensing (optical and non-optical methods) and multiple discrete observations. A collection of imaging papers has been assembled from this meeting. The papers have been published jointly as a special issue of the Journal for Atmospheric and Solar-Terrestrial Physics (JASTP) in Spring 2000.

Future activities include aeronomic studies based on the restored ISO data as well as increased aeronomic investigations with UVI. ISPAE investigators are also performing cross-instrument collaborative studies with other imager teams on the POLAR spacecraft, for example Ostgaard et al., [2000; 2001].

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