quadrupolar electrostatic potential throughout the surrounding vacuum.

The force on a test particle is purely electrostatic. The corresponding magnetic field line velocity calculated from (1) would twist the magnetic field lines, whereas in reality, they remain undistorted and confined to meridional planes.

Historically, the concept of moving field lines dates to Hannes Alfvén who, in an early paper [*Alfvén*, 1942] noted that in an infinitely conducting medium "the matter of the liquid is fastened to the lines of force." This phenomenon became known as 'frozen-in magnetic field lines' and is a consequence of equation (2) being satisfied because the magnetic field aligned or parallel electric field is zero in an infinitely conducting medium.

The nonexistence of parallel electric fields was later challenged by Alfvén, who suggested that auroral primary electrons may gain their energy from falling through a parallel potential drop above the ionosphere and described how parallel electric fields can 'cut' magnetic field lines. Alfvén's idea was contrary to contemporary beliefs and was almost universally disregarded, but when in situ measurements in space became possible, they brought the first indications that Alfvén might be right. Since then, an overwhelming amount of empirical data have proven that magnetic field aligned electric fields exist and are of key importance in the physics of auroras [*Fälthammar*, 2004], in magnetic field reconnection [*Mozer*, 2005], in shocks [*Mozer et al.*, 2006], and in plasma turbulence and many wave modes.

Alfvén, who had introduced the concept, became a strong critic of 'moving' magnetic field lines [*Alfvén*, 1976], especially in his later years. He warned against use of the concepts of 'frozen-in' and 'moving' magnetic field lines for the reasons that are emphasized above.

The basic reason for these difficulties with 'moving' magnetic field lines is, of course, that motion of magnetic field lines is inherently meaningless. The magnetic field **B** is a vector field defined as a function of space coordinates and time. At a fixed time, one may trace a field line from any given point in space. But that field line has no identity, and in a time-dependent magnetic field it cannot be identified with any field line at a different time, except by one convention or another. As we have seen, such conventions are fraught with pitfalls and should only be used with utmost care lest they lead to erroneous conclusions. To paraphrase Ralph Nader, moving magnetic field lines are "unsafe at any speed."

References

Alfvén, H. (1942), Existence of electromagnetic-hydrodynamic waves, *Ark. Mat. Astron. Fys.*, *29B*(2), 1–7.

Alfvén, H. (1976), On frozen-in field lines and field-line reconnection, *J. Geophys. Res.*, *81*, 4019.

Belcher, J. W. (2005), Bringing space physics concepts into introductory electromagnetism, *Eos Trans. AGU*, *86*(21), 201, 203.

Fälthammar, C.-G. (2004), Magnetic-field aligned electric fields, *Geofis. Int.*, *43*, 225.

Feynman, R. P., R. B. Leighton, and M. Sands (1964), *The Feynman Lectures on Physics*, Addison-Wesley, Boston, Mass.

Longmire, C. L. (1963), *Elementary Plasma Physics*, John Wiley, Hoboken, N. J.

Mozer, F. S. (2005), Criteria for and statistics of electron diffusion regions associated with subsolar magnetic field reconnection, *J. Geophys. Res.*, *110*, A12222, doi:10.1029/2005JA011258.

Mozer, F. S., H. Matsui, and R. B. Torbert (2006), Electron scale size structures are everywhere: Are they electron diffusion regions?, paper presented at the EGU General Assembly, Eur. Geophys. Union, Vienna, 2–7 April.

Newcomb, W. A. (1958), Motion of magnetic lines of force, *Ann. Phys.*, *3*, 347.

Vasyliunas, V. (1972), Nonuniqueness of magnetic field line motion, *J. Geophys. Res.*, *77*, 6271.

Author Information

Carl-Gunne Fälthammar, Alfvén Laboratory, School of Electrical Engineering, Royal Institute of Technology, Stockholm; Forrest S. Mozer, Space Sciences Laboratory, University of California, Berkeley.

NEWS

Ionospheric Challenges of the International Polar Year

PAGE 171

Fifty years ago, the first International Geophysical Year (IGY) generated a huge step function increase in observations of ionospheric variability associated with the almost continuous geomagnetic activity experienced during the largest solar maximum of the past 100 years. In turn, these observations fueled more than a decade of theoretical advancement of magnetospheric-ionospheric electrodynamics and geomagnetic storm physics.

In stark contrast, the current International Polar Year (IPY; 2007–2009) is occurring during what may well turn out to be the deepest solar minimum in 100 years. Potentially, it could be a very geomagnetically quiet period, a period during which ionospheric variability will be driven by processes in the troposphere and mesosphere. Since the variability of the ionosphere-thermosphere system associated with the upward propagating planetary, tidal, and gravity waves from the lower atmosphere is expected to be independent of the solar cycle, the IPY period is an ideal time to study the interchanges between the lower and upper atmospheric regions.

In the polar regions, coupling of the lower and upper atmospheres is usually negligible in comparison with coupling of the magnetosphere and upper atmosphere. However, during the magnetically quiet IPY period, the lower-upper atmospheric coupling could, at times, dominate in the polar regions. The stage therefore is set for 'IGY'-like fiduciary observations that will inevitably drive theoretical progress in understanding coupling of the lower and upper atmospheres. Of particular impor-

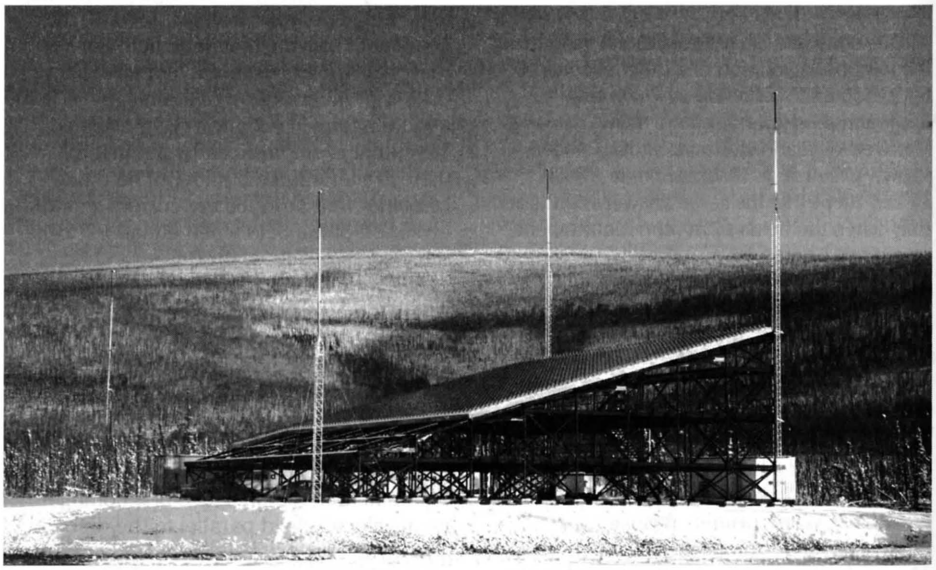

Fig. 1. Advanced Modular ISR, Poker Flat, Alaska (66° 7'48"N, 147°28'15"W).

tance in this regard are the two incoherent scatter radars (ISR) located in the northern polar region that will measure the ionospheric state parameters (density, temperature, and velocity) simultaneously and almost continuously during the entire IPY.

The European Incoherent SCATter (EISCAT) Svalbard Radar (ESR), a powerful ISR in northern Scandinavia, can monitor the ionospheric parameters along the local geomagnetic field lines threading the polar cap, while the newly commissioned (January 2007) Advanced Modular ISR (AMISR) at Poker Flat, Alaska (Figure 2), can similarly monitor the ionosphere on the other side of the polar region. At different times of the day, these radars sample the polar cap, auroral oval, and subauroral ionospheres. Both of these facilities will create a nearly yearlong data set of ionospheric observations (ionization density, electron and ion temperatures, and line-of-sight ion velocity) that began on 1 March 2007.

Many other instruments that monitor the ionospheric and atmospheric regions will augment these two ISR data sets through their normal operational schedules. The Norwegian Research Council has provided incremental funding to allow the ESR to operate essentially continuously during the first year of the IPY. Meanwhile, the ISR facilities at Millstone Hill (Westford, Mass.) and Sondrestrom (Kangerlussuaq, Greenland) will operate for about 32 hours every 2 weeks to sample long-timescale variations not addressed by the previous long runs (~30 days duration) conducted by these radars.

In contrast with the situation during the IGY, the ionosphere can now be described with three-dimensional, time-dependent, physics-based models. However, these models still fail to capture the full variability, and often the climatology, of the region. A recent example of this problem is the *Sojka et al.* [2005] comparison of the Utah State University (USU) Time Dependent Ionospheric Model (TDIM) with a monthlong ESR data set. Given that the described IPY observational campaign will focus on two ISRs operating almost continuously and complemented by extensive ground-based and satellite observations, a unique database will be created that captures the seasonal and shorter-term variability of the ionosphere.

The following challenge is given to the ionosphere-thermosphere modeling community: Can we create model predictions for these yearlong observations? Can we compare predictions with the observations and with each other's predictions to identify model and theory challenges? Can the aeronomy community through focused workshops during the IPY upgrade their models and, most important, the lower atmosphere inputs, and then repeat the prediction-comparison cycle?

The authors will hold a model-observation workshop at the Coupling, Energetics, and Dynamics of Atmospheric Regions (CEDAR) meeting, 24–29 June 2007, in Santa Fe, N. M. Interested modelers are encouraged to contact Jan Sojka (sojka@cc.usu.edu) to establish procedures for making their IPY predictions electronically available.

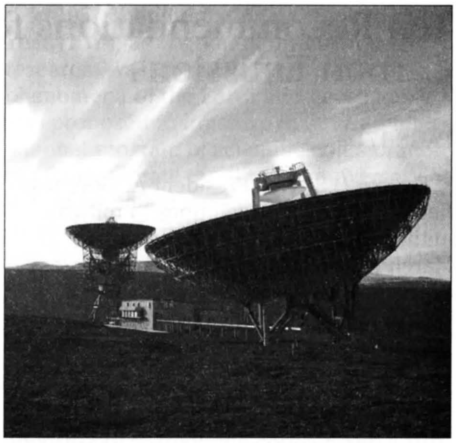

Fig. 2. European Incoherent Scatter Svalbard Radar, Longyearbyen, Svalbard (78°09'11"N, 16°01'44"E).

References

Sojka, J. J., M. David, R. W. Schunk, and A. P. van Eyken (2005), Polar F-layer model-observation comparisons: A neutral wind surprise, *Ann. Geophys.*, *23*, 191–199.

—Jan Sojka and Robert Schunk, Center for Atmospheric and Space Sciences, Utah State University, Logan; Tony van Eyken, EISCAT Scientific Association, Kiruna, Sweden; John Kelly, Craig Heinselman, and Mary McCready, SRI International, Menlo Park, Calif.

International Space Station Supports International Polar Year

PAGE 171

The International Space Station (ISS) provides an excellent venue for observing Earth systems. Starting in March 2007 and coinciding with the beginning of the International Polar Year (IPY), NASA's Crew Earth Observations (CEO) payload invites IPY investigators to submit requests for relevant imagery be collected from the ISS.

Every day, ISS astronauts photograph designated sites and dynamic events on the Earth's surface using digital cameras equipped with a variety of lenses. Depending on observation parameters, astronauts can collect high-resolution (4–6 meter pixel size; see J. Robinson and C. Evans, *Eos Trans. AGU, 83*(17), 185, 2002) or synoptic-view (lower resolution but covering very large areas) digital data in three (red-green-blue) color bands.

ISS crews have daily opportunities to document a variety of high-latitude phenomena. Although lighting conditions, ground track, and other viewing parameters change with orbital precessions and season, the 51.6° orbital inclination and 400-kilometer altitude of the ISS provide the crew a unique vantage point for collecting image-based data of polar phenomena, including surface observations to roughly 65° latitude, and upper atmospheric observations that reach nearly to the poles.

During the 2007–2009 time frame of the IPY, polar observations will become a scientific focus for the CEO experiment; the experiment is designated ISS-IPY. We solicit requests from scientists for observations from the ISS that are coordinated with or complement ground-based polar studies. The CEO imagery Web site for ISS-IPY (http://eol.jsc.nasa.gov/ipy) provides an online form that allows IPY investigators to interact with CEO scientists and define their imagery requests. This information is integrated into daily communications with the ISS astronauts about their Earth observations targets. All data collected are cataloged and posted on the Web site for downloading and assimilation into IPY projects. Examples of imagery and detailed information about scientific observations from the ISS can also be downloaded from the ISS-IPY Web site.

To date, the database of imagery acquired by the Crew Earth Observations experiment aboard the ISS (http://eol.jsc.nasa.gov) contains more than 54,000 images of high-latitude events such as aurora, polar mesospheric clouds, sea ice, high-latitude plankton blooms, volcanic eruptions, and snow cover. Previous scientific collaborations using these data include coordinating observations of aurora with ground-based investigators, observations of plankton blooms with ship-based experiments, imagery of volcanic activity in the Aleutians, and tracking large icebergs over time in the southern oceans.

—Cynthia A. Evans and Donald R. Pettit, NASA Johnson Space Center, Houston Tex.; E-mail: Cindy.evans-1@nasa.gov; Donald.r.pettit@nasa.gov