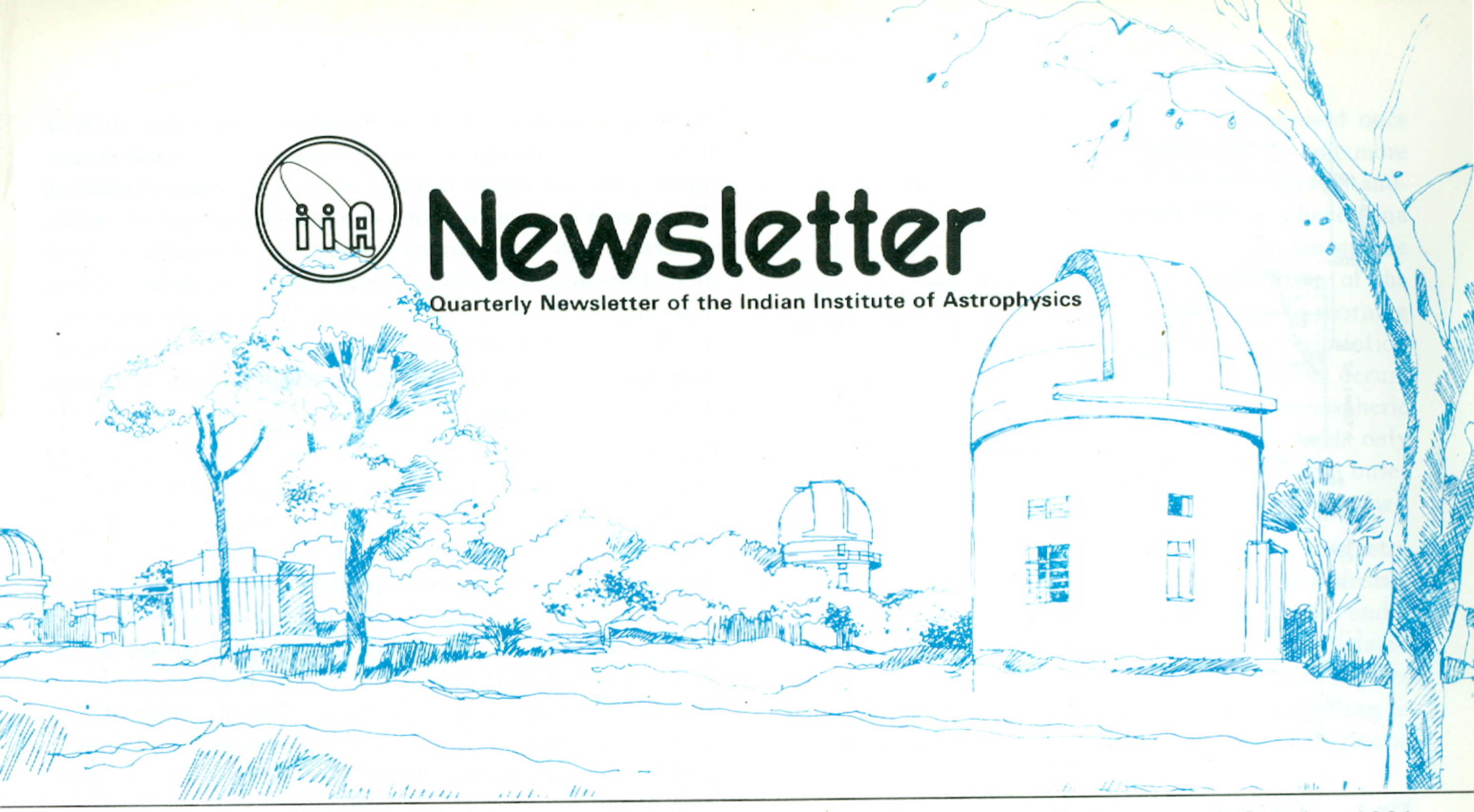

Newsletter

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Ionospheric Electric Field Disturbances associated with changes in Magnetospheric Convection

Magnetic reconnection at the dayside magnetopause is the principal mechanism of energy transfer from the solar wind to the earth's magnetosphere. The solar wind – magnetosphere interaction creates a large-scale circulation of magnetospheric plasma and a potential difference is established across the tail of the magnetosphere. The resulting magnetospheric convection electric field is oriented dawn-to-dusk. The cross-tail potential difference is mapped down the highly conducting magnetic field lines to the high latitude ionosphere as a perpendicular electric field and induces a large-scale motion (EXB drift) of the ionospheric plasma. The polar cap potential drop(typical value $\sim 60\,\mathrm{kV}$; range 10–240 kV) which determines the convection speed is strongly dependent on the magnitude and direction of interplanetary magnetic field (IMF) and solar wind flow speed. The plasma motion induced by the magnetospheric convection electric field also drives a horizontal current at E region altitudes in the high latitude ionosphere owing to the differences in electron and ion drifts. Currents associated with magnetospheric convection thus serve to drive currents in the high latitude ionosphere, and these are coupled in turn to the magnetosphere through field-aligned (Birkeland) currents. In addition to electric fields, auroral electron precipitation, and heat flows generated in the magnetosphere have a dramatic effect on the high latitude ionosphere (Schunk 1983: *Solar-Terrestrial Physics: Principles and Theoretical Foundations*, D. Reidel, Dordrecht, p.609). A strong dynamic coupling thus prevails between the magnetosphere and the high latitude ionosphere. The sub-auroral ionosphere, on the other hand, is shielded from the magnetospheric electric field by the ring current. The basic principle of the shielding is that under the action of the externally imposed dawn-to-dusk potential difference, space charges develop on the inner edges of the ring current creating a secondary potential difference which more or less cancels out the effect of the external potential difference inside the corotating plasmasphere.

Observations over the past decade with incoherent/coherent scatter radars, ionosondes and magnetometers have established the prevalence of transient as well as enduring electric field disturbances in the sub-auroral ionosphere during disturbed geomagnetic conditions. The transient electric fields manifest with simultaneous changes in some of the parameters that are closely linked with the state of magnetospheric convection, such as the orientation of IMF B_z, auroral electroject (AE index) intensities and the time rate of change of the ring current (Dst index). Simultaneous measurements at a meridional network of incoherent scatter radars showed that the transient electric fields are related to rapid changes in magnetospheric convection induced by changes in the direction of IMF B_z, and thus represent 'signatures' of the prompt penetration of high latitude electric fields into the mid, low, and equatorial ionosphere. The experimental work led to the development of realistic theoretical models of penetration electric fields in the sub-auroral ionosphere caused by sudden changes in magnetospheric convection. The global models of Senior & Blanc (1984: *J. Geophys. Res.*,

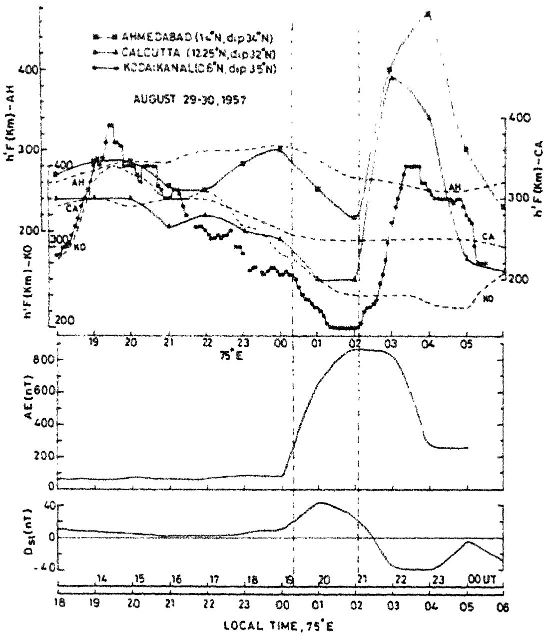

Fig. 1. The time variation of $h'F$ on the night of 1957 August 29/30, with the monthly median pattern superposed for referenc? (top panel).

89, 261) and Spiro *et al.* (1988: *Ann. Geophys.*, **6**, 39) have been fairly successful in explaining the basic characteristics of the penetration electric fields derived from experiment. There are, nevertheless, some areas of substantial discrepancy between theory and observations as well as several ill-understood observational aspects of the penetration electric fields. One such is the fact that the transient electric fields appear either with an increase in magnetospheric convection at the onset of a substorm (due to southward turning of B_z) or with a decrease in convection during substorm recovery phase (due to northward swing of B_z) but not both. This mutually exclusive nature of substorm-phase related electric fields is rather puzzling because, in a typical substorm, increase in convection will be followed by a decrease and the effects of both are to be seen. Explicit evidence for the occurrence of the composite effect predicted by the models (Spiro *et al.* 1988; Fejer *et al.* 1990: *Ann. Geophys.*, **8**, 441) has not been reported so far. We have found the first-ever evidence for the prevalence of a composite electric field disturbance in the midnight-dawn sector near the geomagnetic equator through an analysis of high time resolution (5-min interval) ionogram data of Kodaikanal in conjuction with those at other latitudes, and also high latitude magnetograms (Sastri *et al.* 1991: *Planet. Space Sci.*, in the press).

Perturbations in electric fields and currents in the sub-auroral ionosphere can be studied through their effects on F-region plasma drift and ground-level geomagnetic field variations. An eastward (westward) electric field near the dip equator produces an upward (downward) drift of F-region plasma which can effectively be detected at any time, over the entire diurnal cycle, by measurements of F-region vertical drifts with the incoherent scatter radar. Alternatively, one can use ionosonde measurements of $h'F$, the minimum virtual height of bottomside F-layer, but only for the night time period. At night, the time rate of change of $h'F$ near the dip equator provides reliable and valuable information of F-region plasma drift and hence of the east-west electric field that causes it.

The transient composite electric field disturbance was evidenced at Kodaikanal on the night of 1957 August 29/30, and its signature in $h'F$ is displayed in Fig. 1. The monthly median pattern of $h'F$ reflects the typical behaviour of F-region vertical drift near the dip equator at solar maximum, namely, an enhancement in upward drift (eastward electric field) during post-sunset hours and downward drift (westward electric field) through the remainder of the night till sunrise. On the night of August 29/30, $h'F$ at Kodaikanal underwent the common post-sunset enhancement and followed the median pattern between 2200 LT and midnight. The deviations in the behaviour of $h'F$ from the median noticed in the pre-midnight period (larger values after sunset, lower absolute values between 2200 and 0000 LT *etc.*) are not surprising because the vertical drift is known to display considerable day-to-day variability even on quiet days particularly in the post-sunset period. The deviations are unlikely to be due to external influences such as high latitude and magnetospheric phenomena driven ultimately by the solar wind, because they occurred under very quiet geomagnetic conditions (Fig. 1). In sharp contrast to this pre-midnight behaviour, just after midnight there was a sudden reduction in $h'F$ from 265 km at 0020 LT to as low as 200 km by 0120 LT, *i.e.*, a decrease of 65 km in 60 min or an apparent downward drift of $18\,\mathrm{m\,s^{-1}}$. This value of downward drift is an underestimate because, for altitudes below 300 km, the height increase induced by chemical loss counteracts the height decrease caused by the westward electric field. But the very fact that an apparent downward drift of $18\,\mathrm{m\,s^{-1}}$ prevailed when $h'F$ was in the range 200–265 km is an unambiguous pointer to the presence of intense westward electric fields. Following the rapid decrease just after midnight, the F-region height experienced another more conspicuous perturbation in the form of an abnormal and rapid increase in $h'F$ from 200 km at 0205 LT to 400 km at 0320 LT, *i.e.*, an increase by 200 km in 75 min or an upward drift of $\sim 45\,\mathrm{m\,s^{-1}}$. The entire sequence of a rapid decrease followed a prominent increase in $h'F$ manifested over a time span of just about 3 hr which, incidentally, is the typical duration of a magnetospheric substorm. The values of vertical plasma drift corrected for chemical loss effects showed the maximum amplitude of the westward and subsequent eastward electric field perturbation to be $\approx 2\,\mathrm{mV\,m^{-1}}$.

The time history of AE index showed the occurrence of an isolated auroral substorm of moderate strength starting at 0000 LT, *i.e.,* in excellent coincidence with the perturbation in F-region height at Kodaikanal (Fig. 1). The rapid decrease in $h'F$ is indicative of prominent westward electric fields manifested during the development phase of the substorm, and the subsequent abrupt and significant increase indicative of eastward electric fields during its recovery phase. This temporal relationship of the polarity pattern of the electric field disturbance to the substorm phase is confirmed through a study of the original magnetograms of high latitude stations widely separated in longitude. The electric field disturbance finds a logical and straightforward interpretation in terms of low latitude penetration of substorm-related perturbations in high latitude electric fields. The most recent modelling results (Fejer *et al.* 1990) indicate that in the midnight-to-morning sector, transient westward/eastward electric fields are generated near the geomagnetic equator due to an increase/decrease in magnetospheric convection or polar cap potential drop. A composite disturbance with westward fields around the onset of substorm and eastward fields in its recovery phase is therefore expected to occur at locations like Kodaikanal, which is exactly what is observed. In addition, the $h'F$ data of Calcutta and Ahmedabad amply demonstrate the presence of a disturbance in F-region height of the same nature at the two locations simultaneous with the one evident at Kodaikanal (Fig. 1). The simultaneous occurrence of the same type of disturbance at three locations spanning a latitudinal range of about 14° and in excellent coincidence with the auroral substorm rules out the possible role of neutral wind disturbances, and substantiates the interpretation in terms of penetration electric fields. The possibility that the occurrence of transient composite disturbances in equatorial zonal electric fields at times of substorm activity predicted by the models is not very rare (as one is led to infer from the literature available on the subject) is indicated by bringing into the light the evidence for such a disturbance in the published data of F-region plasma drift obtained with the incoherent scatter radar at Jicamarca, Peru.

It is instructive to consider the reasons for the lack of information hitherto of the substorm-related composite disturbances in sub-auroral electric fields during night time. The first one is an obvious selection effect arising from the use of ionosonde data by a majority of the researchers. It is quite easy to detect night time increases in $h'F$ that predominantly occur during the recovery phase of substorms, because they are usually prominent and, more importantly, are anomalous being in phase opposition to the normal diurnal pattern. On the other hand, decreases in $h'F$ that occur in the substorm development phase can at best be of only moderate amplitude and occur superposed on the normal pattern. They are thus not readily noticeable but can be recognised once noticed as demonstrated by us. The second and more important reason is our current inadequate understanding of the subtle aspects of magnetospheric phenomena and the apparently complex magnetosphere-ionosphere interactions. For example, if the intensification of the westward auroral electrojet in the midnight-to-morning sector is predominantly caused by particle precipitation and the enhancement of the auroral electric fields occurs after the maxima in particle precipitation and ionospheric conductivity, then transient eastward electric fields only will prevail delayed with reference to the substrom onset (which is what is widely reported in the literature so far).

The comprehensive study of the solar-wind–magnetosphere–ionosphere coupling is one of the major themes of research currently being pursued worldwide under the Solar-Terrestrial Energy Program (STEP) formulated by the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) of ICSU. Our group will be contributing to the national efforts related to STEP with the experimental facilities at Kodaikanal and Kavalur observatories.

J. Hanumath Sastri

Role of Shear Magnetic Field Lines in Flaring Regions on the Sun

It is currently believed that the primary source of energy released in solar flares is free energy stored in stressed (sheared) magnetic fields. The release of this energy occurs in the transition from the sheared configuration to the potential field configuration. The shear angle is defined as the angle in azimuth between the observed magnetic field and the potential magnetic field. The shear angle of the neutral line of the non-potential magnetic field have been derived from Kodaikanal data for one or two days prior to and after the flare for 10 flare events using the Hα filament positions. It is evident from the samples studied that it is the change that occurs in the shear a day prior to the flare that can lead to the event. This change can be in either direction, *i.e.*, it can be a large increase from a small value or a decrease from a large initial value. A large value of the shear angle alone need not be a prerequisite for the flare event to occur. In the sample studied there is one instance where there was no significant change in the shear angle and this region did not produce any flare. This further strengthens the conclusion from the study of the remaining nine regions.

K. R. Sivaraman, R. R. Rausaria & S. M. Aleem

Hα Variability in the Quiescent Spectrum of the Recurrent Nova T Coronae Borealis

T Coronae Borealis is a recurrent nova with two recorded outbursts in 1866 and 1946. It is an interacting binary with a cool, mass-losing secondary and a hot accreting primary. The orbital period is 227.53 days. The ultraviolet (UV) spectrum observed by the International Ultraviolet Explorer (IUE) during quiescence is dominated totally by the hot component that appears to be an accreting white dwarf. The spectrum consists of high and low excitation permitted and intercombination emission lines, shell-like absorption lines, and a power-law continuum. Both the spectral index and the integrated UV luminosity vary with time (Selvelli, Cassatella & Gilmozzi 1991: *Astrophys. J.*, in the press). The quiescent optical spectrum is that of the M III secondary, with superposed emission lines which are also variable (Kenyon & Garcia 1986: *Astr. J.*, **91**,125). Photometry of T CrB during quiescence has shown ellipsoidal variations of the tidally distorted secondary (Bailey 1975: *J. Br. astr. Assoc.*, **85**, 217). No correlation could be found between the optical and UV spectrum variability and orbital phase since the available data were scanty.

T CrB is being monitored spectroscopically at IIA since 1985 using the Cassegrain UAG Spectrograph at the 1 m reflector of VBO. Image-tube photographic spectra were recorded till 1985. CCD spectra are being recorded since 1989 December. The spectral resolution is about 10 Å. The variability of emission lines was studied using the spectra obtained over the baseline of 1985–90. Only equivalent widths were used in the analysis since the majority of spectra were photographic without accurate flux calibration.

The Hα emission increased steadily from 1985 to 1986 September, and decreased thereafter reaching in 1987 July a value less than that observed in 1985. The total variation had a range of 2–37 Å in equivalent width. In order to look for orbital phase dependent modulation, a smooth curve passing through the minimal equivalent widths in each orbital cycle was taken to be the base-level secular variation, and the equivalent widths were normalized by division by this curve. This brought out orbital variations with peaks near phases 0 and 0.5 with a contrast of 1:2.5. The increase in Hα emission was evident at these phases during all the cycles, whenever the spectra were available. The lines of He I were strong during 1986-87 at the peak in the secular activity. During this period, one orbital cycle was covered fairly well. The observations during that cycle showed the increased emission near phases 0 and 0.5 for Hα, Hβ, and He I 5876 and 6678 Å. The decrease in the continuum at these phases reported by Peel (1990: *J. Br. astr. Assoc.*, **100**, 136) can explain only a small fraction of the observed increase in equivalent width.

The cause of these variations can be ascertained only through detailed modelling of the UV and optical spectrum of the hot component. A good phase coverage over this extended range, including moderate resolution line profiles are needed to this end.

A detailed paper will appear in the *Monthly Notices of the Royal Astronomical Society.*

G. C. Anupama & T. P. Prabhu

Hydrogen Line Ratios in the Seyfert Galaxy NGC 4151

We are computing hydrogen emission line ratios in the Seyfert galaxy NGC 4151 by assuming blackbody radiation. A neutral gas density, $N = 10^2$ cm^{-3} and electron density, $N_e = 10^3$ cm^{-3} (Penston *et al.* 1990: *Astrophys. J.*, **236**, 53) were assumed and the Boltzmann equation was used to calculate the number of excited atoms forming the lines. The temperature T and gas velocity V used in the calculation are listed in Table 1. We have taken the inner and outer radii to be 1 and 4 light days, respectively, following Clavel *et al.* (1990: *Astrophys. J.*, **366**, 64).

Table 1. Line ratios and FWHM for different temperatures and velocities of expansion.

T	V_{th}	V	$\frac{H_\alpha}{H_\beta}$	$\frac{H_\gamma}{H_\beta}$	$\frac{H_\delta}{H_\beta}$	FWHM (km s^{-1})			
10^3K	km s^{-1}		Hβ = 100			Hα	Hβ	Hγ	Hδ
13	14.97	900	268.98	54.91	36.86	149.41	134.47	134.47	134.47
11	13.77	900	438.18	42.95	25.29	73.92	147.84	147.84	147.84
10	13.13	700	615.42	38.35	21.75	99.67	117.25	134.84	99.67

Due to the uncertainty in the physical quantities such as temperature, number density, velocity of expansion *etc.*, we have tried to get the physical effects due to temperature and velocity changes on the ratios Hα/Hβ, Hγ/Hβ and Hδ/Hβ. We find that (1) the ratio Hα/Hβ decreases as the temperature increases; this trend is reversed for Hγ/Hβ and Hδ/Hβ; (2) there seems to be practically no change in the ratios due to velocity changes. It is perhaps because the line widths are more affected by the number of atoms available in a given state of excitation. The results are summarized in Table 1. The observed and corrected values of the ratios (Penston *et al.* 1990) are Hα/Hβ = 265, Hγ/Hβ = 43 and Hδ/Hβ = 17. It is apparent that these ratios are obtained in our calculations but at different temperatures.

Prabhjot Singh & A. Peraiah

C. Sivaram was invited to give a course of lectures on Black Hole Physics, at NATO Advanced Study Institute in May 1991. He was also invited to give a talk on the cosmological constant problem at the international symposium in honour of the 75th birthday of Peter Gabriel Bergmann.

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The following scientists participated in the 21 IAU General Assembly, held at Buenos Aires, and delivered the following lectures. A. Peraiah: Departure from sphericity in stellar atmospheres. Sushma Mallik: The Hα line as a diagnostic of cool supergiant chromospheres. G.S.D. Babu: (1) Masonary instruments at Delhi Jantar Mantar and the programme for their restoration; (2) Antarctic Astronomy. J.C. Bhattacharyya also participated in the IAU General Assembly. Sushma Mallik took part also in the special panel discussion on Women in Astronomy. G.S.D. Babu also visited Argentina Institute for Radio Astronomy near La Plata and gave the following talks: (1) Optical astronomy in India; (2) Solar observations from the Indian station in Antarctica.

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J. C. Bhattacharyya has been elected as the **President of IAU Commission 9 on Instrumentation and Techniques**. He has also been nominated as the **Chairman** of **SCOSTEP** (Scientific committee on solar-terrestrial physics), INSA, New Delhi for a three year term from July 1991.

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A. Peraiah visited PRL, Ahmedabad, in August 1991, and gave a colloquium and a few seminars.

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R. Pratap, Department of Physics, Cochin University, has joined IIA as a visiting professor for a period of three months since 16 September 1991. P. Bhaskaran, Post-doctoral Fellow, PRL, Ahmedabad, visited IIA for a period of three weeks since 6 August 1991. Both Pratap and Bhaskaran are collaborating with Vinod Krishan.

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Kavan Ratnatunga, Institute for Theoretical Studies, Kandy, Sri Lanka, visited the Institute for a period of two weeks in August/September 1991.

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R. K. Kochhar paid a 5-week visit (20 August – 28 September 1991) to Britain to consult archival material on the history of modern astronomy in British India. His visit was sponsored by the British Council division of the British High Commission and additionally supported by Charles Wallis India Trust and IIA.

David L. Lambert, University of Texas, Austin (USA) visited the Institute between 6 September and 2 October 1991. He continued the ongoing collaboration with N. Kameswara Rao and Sunetra Giridhar on hydrogen-deficient stars.

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W. Kalkofen, Center for Astrophysics, Cambridge, USA, visited IIA during 15–21 September 1991. S.S. Hasan is spending his sabbatical leave at CfA, since July 1991. He is collaborating with Kalkofen.

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The installation of the antennas for the radio telescope at Mauritius, a joint venture of the IIA, RRI and the University of Mauritius, has been completed. Ch.V. Sastry left for Mauritius on 24 September 1991 to continue his collaboration on the project. **A. Peraiah** has assumed charge as **Acting Director** since then.

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J. C. Bhattacharyya delivered the inaugural address at the Indo–US Mini Workshop on Interplanetary Scintillations and Propagating Solar Disturbances, held at PRL, Ahmedabad during 25–26 September 1991. The other participants were M. H. Gokhale and V. Krishan.

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J. H. Sastri participated in the DST meetings on International Equatorial Electrojet Year (IEEY) and Global Electric Circuit (GEC) held at the Indian Institute of Geomagnetism, Bombay during 26–28 September 1991.

* * *

Following staff members have been promoted since 1 October 1991: K.K. Scaria as Principal Scientific Officer, A.V. Raveendran as Reader, K.N. Nagendra, S.K. Saha, K.E. Rangarajan, D.Mohan Rao and N.Surendiranath as Fellows, and K.B. Ramesh as Scientific Officer (SC).

* * *

J. Gethyn Timothy, Thomas E. Berger, both from Stanford University, USA, and Martin C. E. Huber, ESTEC, the Netherlands, visited the Institute on 30 eptember and 1 October 1991, in connection with the third design review meeting of the EUV spectroheliometer payload project.

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Three new research scholars have joined IIA during the current academic year: G. Pandey, R. Ramesh and A.V. Thampan. They are undergoing the course work. Four research scholars have completed their course work and decided on the general area of their work. Annapurni Subramaniam will work under the supervision of Ram Sagar, B. Eswar Reddy with M. Parthasarathy, D. Banerjee with S.S. Hasan, Uma Gorti with H.C. Bhat, S.K. Sengupta (CSIR JRF) with A. Peraiah, and R.D. Prabhu (JAP) with Vinod Krishan. The Institute has continued to participate in teaching at Bangalore

University and Joint Astronomy Programme, Indian Institute of Science. M. H. Gokhale and P. Venkatakrishnan taught at BU and Vinod Krishan taught at JAP during August-September 1991.

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IIA is cosponsoring the sixth national symposium on science and technology of plasmas (PLASMA 91) at CAT, Indore, during 17–21 December 1991. A winter school in astronomy and astrophysics will be held at VBO during 23–31 December 1991. The local coordinator for the winter school is K. K. Ghosh, Vainu Bappu Observatory, Kavalur, Alangayam 635701, N. A. A. District, Tamil Nadu. A mini-workshop in Plasma Astrophysics, funded by IUCAA, Pune, will be held at IIA during 2–6 March 1992. Contact: Vinod Krishan, IIA, Bangalore.

Lecture Notes on **Radiative Transfer in Stellar Atmospheres** by **A. Peraiah** are available free of cost from the Librarian, Indian Institute of Astrophysics, Bangalore 560034.

Colloquia

The following lectures were given at IIA between 1991 August 1 and October 1:

1. The radio emissions from the magnetized planets (Yolande Leblanc, Observatoire de Paris, Meudon, France).
2. High latitude galactic Cirrus clouds (R. Guhathakurta, Institute for Advanced Study, Princeton, USA).
3. Statistical analysis of star catalogs (K. U. Ratnatunga, Institute for Fundamental Studies, Kandy, Sri Lanka).
4. (i) Is there CN-cycled material in the atmospheres of early B-type stars? (ii) Boron in the early galaxy — galactic or primordial? (iii) Origins of p-process nuclei. (D. L. Lambert, University of Texas, Austin, USA).

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