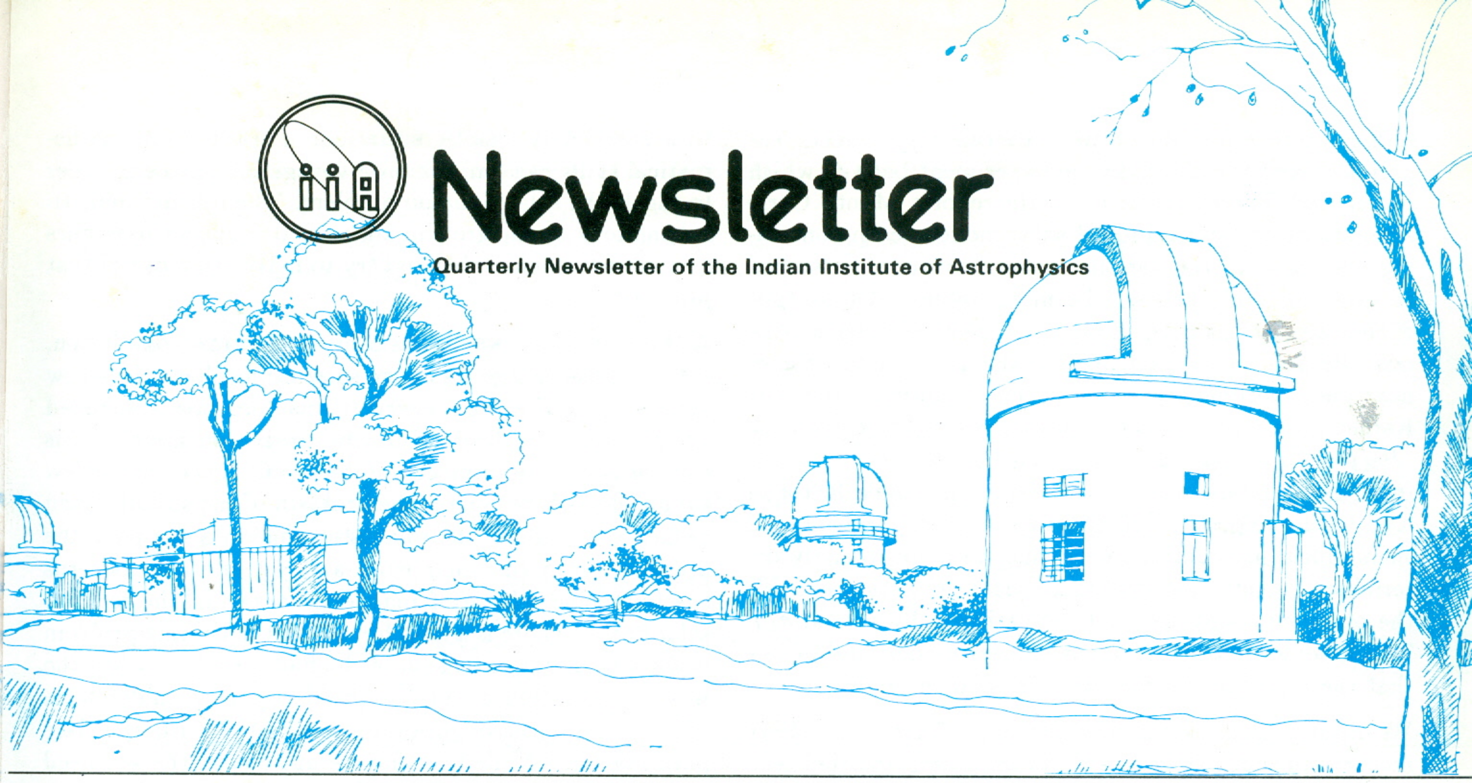

Newsletter

Quarterly Newsletter of the Indian Institute of Astrophysics

Volume 9 Numbers 1–2 April 1994

Solar Physics in the Nineties

The sun is our own star, its close proximity permitting us to study this cosmic laboratory in very great detail, so as to actually verify many of the views expressed by stellar astrophysicists on stars in general. The sun does provide headaches to such theorists, but it provides reassurance, too, for many of the concepts held dearly to by the stellar physicists. Secondly the fate of earthbound humans is closely linked to the subtle variations in the sun's energy output and it is imperative that we closely watch the tiny excursions of this energy output and find out about long term trends in these variations well before the earth becomes too hot a place for habitation. On shorter time scales, we must learn to keep our planet even more tidy than we thought we had to since all the concerns of environmentalists about global warming are based on a constant solar output! Last but not the least, the sheer variety of possibilities of solar observations offers such a challenge to the seeker after truth, that it is a poor scientific performer who does not wish to rise to this challenge.

Key problems in solar physics

The most striking problem is the so-called solar neutrino problem. This problem arose as a consequence of a new mode of solar observations, viz. solar neutrino measurements. In the mid sixties R.Davis had the clever idea of detecting neutrinos using the reaction $^{37}Cl + \nu \rightarrow ^{37}Ar + e^-$.

The Cl was provided as a tank of C_2Cl_4, a dry cleaning material, deep underground in some unused mines. This location screened out many of the other cosmic ray particles leaving behind only the neutrinos. The C_2Cl_4 was periodically flushed out and the Ar content was measured. This gave the number of neutrinos detected. Knowing the cross section for the reaction and the mass of detector available, one can estimate the neutrino flux.

Now, the neutrinos, in turn are generated as a consequence of the thermonuclear reactions taking place within the sun's interior. There are the main $4p \rightarrow \alpha$ fusion reactions, and there are some branch reactions. The main reactions produce low energy neutrinos, while the branch reactions produce high energy neutrinos. The Cl experiment responds only to high energy neutrinos. The neutrino problem arose when the Cl experiment detected only 1/3 of the expected number of neutrinos (expressed in SNUs). This created a flurry of theoretical activity, checking and counter checking etc. The conclusion was that, probably the branch reactions need modifications in the theory, these are sensitive to temperature, so a slightly cooler core would reduce the neutrino output, and so on. Scientists were also designing better experiments based on Gallium that would detect the low energy neutrinos of the main reactions. Recently, these experiments have started yielding results, but these are detecting only about 50% of the expected number. So the solar neutrino problem continues to exist.

What could be the solution? In a recent article to appear in the proceedings of a conference held in March 8-12, 1993 at Trieste, Italy, John N. Bahcall makes an interesting intercomparison of two experiments – the Cl experiment and the Kamiokande experiment both of which detect high energy neutrinos. He reports Monte Carlo simulations of 1000 standard solar models, each containing one value of the various model parameters assumed to vary randomly around the mean values. The output of the calculations is the number of expected solar neutrinos. He first shows that none of the 1000 models comes near the experimental results. Then he assumes that the Kamiokande flux is correct. This gives the flux from the $^7Be(p,\gamma)^8B$ reaction alone and is 0.48 times that expected from the standard model. He applies the same factor of 0.48 to the expected ^8B flux in the Cl experiment and then adds other contributions that are more robustly determined. Even then, the theoretical prediction exceeds the observed counts in the Cl experiment by several σ_{Cl}. This is somewhat independent of solar models and proves that the ν problem is real and not solar in origin.

We must then look for new physics. There is a MSW mechanism that exploits oscillations of neutrinos between different flavours that could account for all the known solar neutrino experiments with a neutrino mass difference (≈ 0.003 eV) that is consistent with current theoretical ideas regarding physics that might lie beyond the standard model. Future experiments like Super-Kamiokande, the SNO and the ICARUS will measure the energy spectrum of ^8B neutrinos and give truly solar model independent comparisons of the Cl and Kamiokande results. There is an urgent need for those with a strong aptitude in particle physics to work in this area. This would be one of the very rare cases where new physics comes, not from the laboratory, but from the Heavens!

The other problems, albeit less exciting in nature, are nonetheless challenging. One such problem is the understanding of the so called solar dynamo – the mechanism for producing the magnetic fields that are observed on the sun and mainly in sunspots. These spots wax and wane in number with a 11 year period and alternate their magnetic polarities every 11 years. Phenomenological models have been suggested to describe these changes in physical terms but no theory exists that explains these happenings. The reason for this difficulty is straightforward: the long term effects are manifestations of large scale phenomena, but the physical processes involved in the creation and anihilation of magnetic flux undoubtedly occur on microscopic scales. A brute force theoretical simulation is out of the question, being limited by numerical inaccuracies and computing power. Clever ways of parametrizing the microscopic effects have not led to any success so far. This being the case, any thoughtful work on the means of tackling diffusive mhd problems with an intrinsically small value of diffusion, but involving large timescales that make this diffusion significant, is welcome. An added complication is that the nonlinearities of the problem lead to cascading of energy into small scales and to a completely chaotic situation. Persons with mathematical skills can embark on a voyage into chaos in order to tackle the solar dynamo problem. The less mathematical can look at the growing data set on sunspot dynamics as a statistical ensemble and try to make sense out of that jumble of facts.

A third problem, which has a more practical complexion, is that of the energetics of the solar atmosphere. It is now agreed upon that this energetics is somehow controlled by the magnetic field. But the precise manner of this control is still beyond comprehension. There are a few subproblems here: one is the problem of the so called non radiative heating of the solar atmosphere, a second is the acceleration of the solar wind and yet another concerns the impulsive release of magnetic energy in the form of solar flares. There is a fond hope that the heating problem is the low energy extension of the flare problem, while the wind acceleration could be considered as a milder form of the solar ejective processes associated with the flare phenomenon. While this may be quite nice, the sun need not behave in a way so as to provide the least mental exercise to the researcher!

The theoretical tasks here are in understanding nonequilibrium thermodynamics, magnetic reconnection and the relationship between macro and microphysics especially in dealing with plasma processes in a highly turbulent medium. The observations involve clever ways of determining magnetic and velocity fields, as well as combining different modes of observation, i.e. optical, radio, X-ray and γ-ray observations. The practical aspect comes from the effects of solar flares on the terrestrial environment, from the effect of the changing solar UV output on the outer atmosphere and from the effect of the changing solar luminosity on the terrestrial climate.

One final, but very hot topic is helioseismology - the science of diagnosing the internal solar structure from the spectrum of sound waves excited by various turbulent and impulsive processes. The methodology here has been very systematically worked out, but this does not prevent a clever mind from coming out with new ideas on this topic.

The course of solar physics in the nineties

Theoretically, there are no obvious breakthroughs on the horizon. Simulations are becoming more and more complicated. The idea seems to be to construct a computer code, increase the complexity of the physics in various stages and produce movies that look like the real thing. As mentioned earlier, studies of chaos and bifurcations would be quite useful.

A robust and consistent way to treat large scales and small scales together in any computation, if developed, would be a real boon to solar physics. Sharpening helioseismological inversion techniques would be one area of intense activity.

A fact relevant for Indian effort in this direction is the choice of Udaipur as one of the sites for the GONG project.

Another completely different area would be that of image restoration. The atmospheric turbulence degrades the solar images and a challenging problem is that of restoring these degraded images. The solar image reconstruction problem is more difficult than the stellar one because we are dealing here with extended images that are troubled by windowing effects. These also have much lower contrasts. There are some beautiful mathematical problems that can be tackled here. The resultant increase in angular resolution will provide completely new insights into some of the problems mentioned earlier.

The question of magnetic reconnection was already mentioned. Although this has been studied earlier in some detail, the new X-ray observations from YOHKOH will provide new impetus to study this problem in a more comprehensive manner. Specifically, one would like to focus on the macroscopic signatures of this microscopic process. Likewise the problem of magnetoconvection of a radiating plasma will receive serious attention in the years to come.

In the case of observations, a whole array of spaceborne telescope, e.g., SOHO, HESP and MSV-1 await launch. The paradigm will shift to the study of the heliosphere as a whole with the sun as the source of energy and particles. This is a rich new field of astrophysics and many of us can profit by enlarging our vision to encompass the heliosphere as an object to be studied in totality. Ground based support for these missions would include magnetic field measurements, radio mapping of coronal mass ejections, and radio scintillation measurements which track these ejecta out through the solar system. In this connection, it must be remarked that we in India have acquired some expertise in magnetography as well as in solar radio astronomy (cf. Gauribidanur facilities). With the promise of GMRT also in the offing, joint optical/radio observations of the sun would be a central effort in the new theme of heliospheric physics and would yield rich dividends for individuals and their groups. Needless to say, with the increasing ambitions of the Indian space programme is associated an increasing need to understand solar activity that controls the near-earth space environment.

Conclusions

Solar physics is ready to take off into various new directions both theoretical and experimental. We in India are well poised to meet the challenge in particular areas. It only requires the influx of large numbers of young and enthusiastic people with creative minds into this enterprise. Let us grasp the new opportunities and plunge into an exciting area of intensive physics activity.

P. Venkatakrishnan

Internationl Conference on Non-Accelerator Particle Physics

The international conference on Non-Accelerator Particle Physics held on the premises of IIA during 2–9 January 1994, was attended by well over 200 participants across the globe. The conference was inaugurated by B. Barish and ended at VBO, Kavalur with the valedictory address by A. Wolfendale. There was also a public lecture at Bangalore by R. Penrose. Apart from intense academic sessions, there were two cultural programmes, a Veena and Sitar Jugalbandhi and an Indian classical dance exposition. The visit to VBO had a lunch interlude at picturesque Krishnagiri reservoir. A summary of the academic programme is given in the following.

The session on *Perspectives on Particle Physics* included three talks — D. B. Cline on New detectors for astroparticle physics: ICARUS and novel WIMP detectors, J. C. Pati on Unification at 10^{-33} cm, and G. Rajasekaran on Is there a future for high energy physics.

Two talks focussed on *Atomic and Nuclear (non-accelerator) Probes of Physics beyond the Standard Model.* N. Fortson gave an overview of the searches for parity and time-reversal violations in atoms, and showed that the results of several atomic parity violation experiments are in agreement with the standard model. R. Cowsik discussed the significance of double-beta decay experiments on Tellurium and Selenium nuclei that he carried out with his collaborators at Washington University, St. Louis. The tellurium experiment gives a limit on mass of the Majorana neutrino ($<$1.1–1.5 eV). Both experiments are capable of measuring decay life times of $\sim 10^{26}$ years, and if a decay is observed at that level, then it would constitute a signature of new physics beyond the standard model.

The first two talks in the session of *Discrete Symmetries in Atoms* were sequels to the talk given by Fortson. J. Guena and Sudha Murthy described novel optical experiments to detect parity and time-reversal violation respectively in atomic Cesium. Both of those experiments can in different ways test the validity of the standard model. Bhanu Das discussed the theoretical foundations of atomic electric dipole moments. He used the results of latest experiments and theory to throw light on physics beyond the standard model. K. S. Babu presented a very interesting supersymmetric CP violation which at low energies predicts electron and neutron electric dipole moments that are not very much below the present limits.

In the session on *Foundations of Quantum Mechanics,* R. Penrose proposed an unconventional explanation for the collapse of the quantum mechanical wave-function. Based on considerations of time-asymmetry in the second law of thermodynamics and cosmology and from the quantum gravity origin of these phenomena he argued that the collapse of the wavefunction must also be a quantum gravity effect. The central theme of the talk by J. Anandan was the reality of the quantum mechanical wavefunction contrary to conventional wisdom. He proposed experiments to measure the wavefunctions of a single particle as well as many-particle systems. D. Home reviewed the present status of quantum non-locality. He suggested an experiment using correlated systems from nuclear heavy-ion reactions to test quantum non-locality. A. J. Leggett discussed the validity of quantum mechanical concepts in the macroscopic realm. He considered examples from the quantum measurement process and superconductivity.

The session on *Gravitation and Feebler Forces* included talks by J. Weber on Gravitational radiation antennas and supernova 1987A observations, C. S. Unnikrishnan on Present status and future directions in experimental studies of composition dependent feeble forces, and K. C. Wali on Non-Abelian monopoles in curved spacetime.

The session on *Dark Matter in the Universe* started with P. B. Price making a case for WIMPs as the constitutent of the dark matter in the universe. Price described the various ongoing and upcoming laboratory searches for WIMPs. New detectors being developed for these searches will be able to sense the recoil atoms struck by WIMP penetrating the earth. Price reported that certain kinds of WIMPs such as massive Dirac neutrinos which would scatter coherently from nuclei have already been ruled out. R. Nityananda focussed on gravitational aspects of dark matter by treating it as a collisional self-gravitating system and pointed out several subtleties associated with the phenomenon of violent relaxation in such systems. D. Narasimha discussed the subject of gravitational lensing as a probe of the existence and distribution of dark matter in the universe. He also discussed the recent announcements by the MACHO and EROS groups of possible detection of dark compact objects in the halo of our Galaxy by the gravitational microlensing method. The dark matter candidates from particle physics point of view were discussed by M. Drees who presented detailed calculations of various interaction cross-sections of the lightest supermassive particle (LSP) with matter, the LSP being a strong candidate for WIMP.

There were four sessions devoted to particle physics, cosmological and astrophysical aspects of *Neutrinos*. The talks by R. N. Mohapatra and J. W. F. Valle dealt with the implications of massive neutrinos for physics beyond the standard model. The former speaker highlighted certain models that can accommodate massive neutrinos, while the latter focussed on several new phenomena that are consistent with the present limit on neutrino masses. P. Roy discussed the possible existence of unstable neutrinos with mass $\sim$ 100 GeV and the methods used to produce and detect them in laboratory. These talks were complemented by two comprehensive reviews on the present status and future prospects of the neutrino mass measurements by W. Stoeffl and T. Bowles. It was evident from Stoeffl's talk that there are problems associated with extracting the mass of the electron neutrino from tritium beta decay experiments and if the three families of neutrinos mix then the neutrino oscillation experiments would provide the best limits on neutrino masses. B. Barish presented the features and performance of the MACRO detector with special reference to neutrino physics. He discussed the results obtained from early runs with the partially complete detector for neutrinos from stellar collapse, atmospheric neutrinos, and the search for high-energy astrophysical point sources of neutrinos. There was a proposal on the possible existence of a new class of Majoron emitting double-beta decays and also a suggestion for detecting them experimentally, by C. P. Burgess. R. S. Raghavan spoke about a novel neutrinoless double-beta decay experiment using ^{136}Xe which is capable of measuring sub-eV Majorana neutrino masses. K. Nakamura presented the latest results of the atmospheric neutrino anomaly observed in Kamiokande. The anomaly is significant in the low momentum region. A. Burrows elaborated on the role of neutrinos in supernova explosions, including a mathematical formalism and preliminary numerical results.

Coming to neutrino astrophysics, almost one entire day's programme was devoted to the *solar neutrino problem*. The combined analysis of SAGE which began in 1985 was presented by T. J. Bowles and indicates that new neutrino properties are the likely cause of the problem, although it is still not possible to completely rule out astrophysical explanations. The results of GALLEX collaboration, in operation since May 1991, which nets 17 months of exposure in 21 successful runs, were reported by T. Kirsten. One concludes that (66–71)$\pm$13% of the total expected signal is due to neutrinos produced in the proton-proton fusion reaction in the sun, constituting the first 'observation' of hydrogen fusion in a star. The results on solar neutrinos from 627 live detector days of Kamiokande-III observations were presented by K. Nakamura. Combined with 1040 live detector days of Kamiokande-II result, the ^{8}B solar neutrino flux relative to the standard solar model prediction by Bahcall and Ulrich is $0.50^{+0.04}_{-0.05}$. Data from the Kamiokande detector were also used to set upper limits on fluxes of low-energy neutrinos from possible nearby sources within or near our Galaxy. D. L. Wark reported the progress of the commissioning of the Sudburg Neutrino Observatory. D. R. Morrison reviewed solar evolutionary models and solar neutrino experiments, and S. Pakvasa reviewed neutrino masses and mixings. The discrepancies between the observed and predicted solar neutrino spectra were discussed by R. J. N. Phillips.

During the session on *Cosmology and Astroparticle Physics*, the current status of cosmic microwave background radiation observations and their reliability were reviewed by R. B. Partridge. Gravity waves as probes of the early universe (grand unification era) was discussed by V. Sahni. J. P. Ostriker gave a post-COBE factual review of the observations and concluded that there is no reason to believe in non-baryonic dark matter. B. Datta discussed neutron stars as cosmic non-accelerator hadronic physics laboratory, and showed that observed pulsar glitch data yield information about the behaviour of high-density hadronic matter.

One full day was devoted to *High Energy Astrophysics,* in particular, high energy cosmic rays, γ rays and neutrinos. J. Ryan summarized the latest results from GRO launched in April 1991 highlighting the discovery of the isotropy of the γ-ray bursts. Other findings of GRO include the several-hour emission of γ rays from solar flares, the non-uniform ^{26}Al emission from the galactic plane, the imaging of solar neutrons, and the detection of ^{57}Co from SN 1987A. G. Yodh gave a status report on TeV and PeV γ ray astronomy with special reference to the next generation of experiment with MILGARO water Cerenkov detector. H. Bradt described XTE scheduled for launch in late 1995 for studying compact galactic and extragalactic objects and various kinds of transient phenomena in x-ray with time resolution of 1 microsecond.

On the session on theoretical and phenomenological studies of high-energy cosmic rays, Rohini Godbole reviewed in detail the possible origins of the observed anomalously large muon content of photon-induced cosmic ray air showers. She concluded that although recent data from e^+e^- colliders indicate an enhancement of total γp cross-section at high energies due to the 'strong' interaction of photons (through the parton content of photons). The enhancement is not large enough to explain the 'muon puzzle' and so alternative explanations must be sought. K. O. Theilheim described his work investigating the dynamics of electrically charged particles in strong electromagnetic fields in the context of studying new acceleration mechanisms for generating very high-energy cosmic rays. A. W. Wolfendale discussed the question of the possible existence of anti-matter in the universe. By using the available data on the cosmic γ-ray background and considering the fact that the matter-antimatter annihilation would lead to production of γ-rays, he concluded that there is no evidence for a matter-antimatter symmetry on any scale in the universe.

In the session on ultra-high energy neutrino astrophysics, P. B. Price described the progress of the AMANDA project, which, when fully operational, would be able to detect TeV neutrinos from various astrophysical and cosmological sources such as neutrinos from possible WIMP annihilations in the sun, neutrinos from AGN, etc.

(Based on reports by B. P. Das, B. Datta & P. Bhattacharjee)

Study of inhomogeneities in the solar atmosphere

Solar chromosphere is highly structured in appearance. A two dimensional scan of the sun in the H or the K line of Ca II reveals that the chromospheric features (inhomogeneities) seen in emission are the plages, the network elements, the bright points and the regions in between the bright points, the last three characterizing the quiet solar chromosphere. The excess emission seen in these features have a one-to-one correspondence with regions of enhanced magnetic fields at the photosphere. In the quiet chromosphere the emission features that stand out prominently next to the network are the bright points. There have been many observational attempts to look for the energy pulses at the bright points using the H or K line time sequence spectra. Also, there have been parallel theoretical efforts looking for the nature of the waves that manifest in the form of the 3-min oscillations of bright points. Yet some of the important problems related to the heating of the quiet solar chromosphere remain unanswered. In this thesis we concentrate on the study of time evolution of the bright points from an examination of their H-line profiles and attempt to provide answers to some of the crucial problems pertaining to the heating of the chromosphere at the sites of the bright points.

The data for this study is the photographic time sequence spectra in the Ca II H-line region obtained using an Echelle spectrograph at the Vacuum Tower Telescope (VTT) of the Sacramento Peak Observatory on a quiet region around the centre of the solar disc. It is a 35-minute long time sequence of 12 s time interval between the frames and hence there are 177 frames in all. After a visual examination of the spectra we picked out a sample of 30 bright points and 2 network elements along the slit for detailed analysis. Their identity was confirmed through the slit jaw pictures in the K line. We designated these 32 locations as B_1, B_2, B_3, ... B_{30} bright points and B_{31} and B_{32} as the network elements and derived the line profiles. To estimate quantitatively the changes in the profiles during the evolution of the bright points, we derived the five parameters of the H-line profile and made plots of these versus time covering the duration of the sequence. We have examined the plots of all the H-line profiles of the bright points, which although at first sight seem amazingly diverse in their forms during evolution can be sensibly grouped into three classes: Class I bright points show a large intensity enhancements in H_{2V} (I_{H2V}) at their peak brightness phase, as high as 4 times or more the normal value. Class II and III bright points show moderate (about 2.5 times the normal value) and marginal increase in intensity enhancements respectively. We have shown in Fig. 1 the light curves of B_5 (class I), B_{12} (class II) and B_9 (class III). The properties of evolution of the profiles in the 3 classes are as follows :

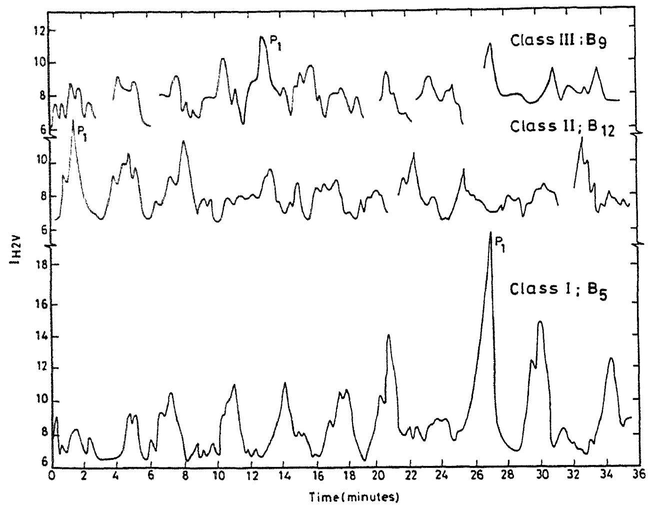

Fig. 1. The variations in the intensity of H_{2V} emission peak (I_{H2V}) with respect to time. The amplitude of the main pulse (P_1) is 4 to 5 times the normal brightness value in class I bright point B_5. It is 2 to 3 times the normal value in class II bright point B_{12} whereas only a marginal enhancement in brightness occurs in class III bright point B_9.

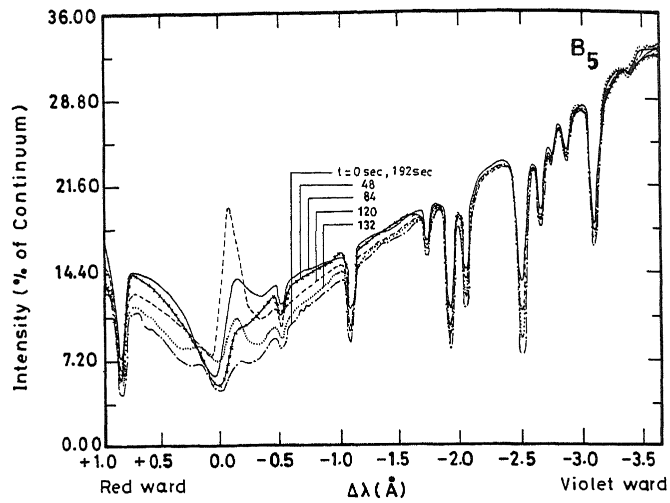

Fig. 2. Evolution of the H-line profile of class I bright point B_5. At $t = 0$s the undisturbed profile shows the familiar shape. At $t = 48$s there is brightening in the far wings. At $t = 84$s the brightening in the far wings has reached simultaneously the H_{2V} and H_{2R} levels and has produced a highly asymmetric profile. At $t = 120$s a very intense single peaked emission has developed at H and at $t = 132$s the wing and the H_{2V} emission start returning to the undisturbed condition.

(a) The plots of I_{H2V} versus time for the Class I, II and III bright points show that the mode of excitation in the bright points starts with a very strong pulse ($I_{H2V}/I_{H2R} \sim 2$) which we call as the 'main pulse' P_1.

(b) We find that 8 more pulses follow the main pulse in class I. For class II and class III, 4-6 follower pulses are most common.

(c) The main pulse has the highest amplitude and the amplitudes of the follower pulses decay exponentially. This pattern is maintained for all the three classes.

(d) The histogram plots and the power spectrum analysis of the main pulses and the follower pulses for the bright points show that their intensity oscillates with a period around 190 s. The period is the same for all the three classes and is independent of the differences in the brightness enhancement even within a class.

(e) The main pulse shows a saw-tooth shape. The follower pulses also tend to show a saw-tooth shape although this becomes less apparent after a few pulses.

(f) The line profiles of class I bright points become highly asymmetric in shape during the passage of the main pulse. Although class II and III bright points do not brighten as those of class I, they show the same degree of asymmetry.

(g) It is argued that the differences in the behaviour of the three classes of bright points is directly linked with the differences in the underlying photospheric magnetic field cospatial with them.

We have traced the sequence of events constituting the growth and decay of the H-line profile of a class I bright point B_5 with respect to time in detail (see Fig. 2). The dynamical process begins as a brightening in the far wings of the H-line and travels towards the higher levels of H_{2V} and H_{2R} simultaneously. When the brightening has reached the H_{2V}level, line profile becomes highly asymmetric with an enhanced H_{2V} peak. This is accompanied by a redshift in H_3 which obscures the H_{2R} emission and keeps it far below the emission in H_{2V}. A little later, the H_{2V} emission fades and merges with the background and H_3 returns to its normal wavelength position. This constitutes one life cycle of the bright point and lasts for about 190 s, after which the whole cycle of events repeats at the same site of the bright point. The profiles of bright points in Class II and Class III also exhibit similar evolution during the passage of the main pulse but with reduced brightness enhancements. Our observations show that the main pulses which propagate upward are the carriers of the energy for the heating of the chromosphere and the bright points are the sites where intense heating takes place. From the Doppler motions of H_3, H_{2V}, and H_{IV} regions during the passage of the main pulse one gets an impression that the H line forming layers are compressed by the approaching layers and this would enhance the temperature and alter the opacity significantly over the ambient values.

It is obvious that the main pulse is the carrier of the energy. We have also estimated the total energy dissipated at the site of the bright points over the entire sun. This energy flux together with that contributed by the network boundary regions work out to 3.4×10^6erg cm^{-2} s^{-1}. This matches well with the emission by the CaII ions estimated as 3.8×10^6erg cm^{-2} s^{-1} in the model calculations by Anderson and Athay (1989, ApJ, 346, 1010). Thus the bright points are the sites where substantial heating takes place and the main pulses transport this energy. We have discussed the physical nature of the wave propagation in the three classes of bright points. The propagation within the bright points of class I which are associated with the strong magnetic field is through a combination of Alfven and acoustic waves with a predominance of Alfven waves whereas the propagation is mainly by acoustic waves in class II and III bright points where the magnetic fields are weak.

Among the 32 sample locations we have analysed, two (B_{31} and B_{32}) lie on the network boundaries. A plot of I_{H2V} versus time for the entire 35-min duration of the sequence for B_{31} and B_{32} shows intensity fluctuations with periods 0.5-1.5 min and superposed on this is a quasi-sinusoidal pattern with a period of 5-7 minutes. This large difference in periods between the oscillations at the bright points and at the network boundaries itself could be taken as an evidence to argue that the mechanism of heating in the two cases are dissimilar.

R. Kariyappa

(Synopsis of the thesis titled 'Study of Inhomogeneities in the Solar Atmosphere' for which the Bangalore University has awarded its Ph.D. degree in April 1993.)

newsline

A.K. Saxena has been awarded the 1994 Republic Day Award for innovative inventions by the National Research Development Corporation under its Invention Promotion programme. The award is for the development of space-worthy passive radiant cooler, which forms a part of the very high resolution radiometer used for meteorological application on board satellites. The first set of coolers is already on board INSAT IIA and another set has already been completed for INSAT IIB. Saxena shares this award with P. P. Gupta and S. C. Rastogi of ISRO Satellite Centre, Bangalore, and Indira Rajagopal of National Aeronautical Laboratories, Bangalore.

colloquia

The following lectures were given at IIA between 1993 July and 1994 April 15:

1. The thermodynamics of blackholes and radiation (Nigel Bishop, Univ. South Africa, Pretoria)
2. The horizons of two blackholes (Nigel Bishop, Univ. South Africa, Pretoria)
3. The development of torsion balances for gravitational research (R.D. Newman, Univ. California, Irvine, USA)
4. Testing the inverse square law of gravity: a new class of torsion pendulum null experiments (Paul Boynton, Univ. Washington, Seattle, USA)
5. Gravitational effects on superconductors (J.S. Anandan, Univ. South Carolina, USA)
6. The meaning of wave function (J.S. Anandan, Univ. South Carolina, USA)
7. Creativity in science and arts (R.L. Kapur, National Institute of Advanced studies, Bangalore)
8. Measurement of global Hubble constant (N. Visvanathan, Mt. Stromlo & Siding Spring Obs., Australia)
9. The recurrent nova RS Ophiuchi (G.C. Anupama, IUCAA, Pune)
10. Coronal mass ejections and metric radio emission (N. Gopalswamy, Dept Astr., Univ. Maryland, USA)
11. From quarks to baryons (S. Sahu, Inst. Phys., Bhubaneswar)
12. Instrumentation for solar research (Li Ting, Nanjing Astronomical Instruments Research Center, China)
13. Galactic bulge planetary nebulae (M.A. Ratag, Indonesian National Institute of Aeronautics and Space)
14. Squeezing of vacuum fluctuations and its applications to experiments (C.V. Sukumar, Oxford Univ., U.K.)
15. Martian polar caps (Kyosuke Iwasaki, Kyoto Univ., Japan)
16. The real value of SLO and the biasing (E. Regös, Inst. Astr., Cambridge, England)
17. The formation of cataclysmic variables and algols (C. A. Tout, Inst. Astr., Cambridge, England)
18. A statistical model for the radiation field of non-interacting stars (H. Parthasarathy, Electrical Engineering Dept, IIT, Delhi)
19. Infrared spectroscopy of discs around young stars (John Carr, Dept. Astr., Ohio state Univ., USA)
20. Activity in galaxies: New theoretical insights (Judith Perry, Inst. Astronomy, Cambridge, England)
21. Some unconventional electric machines (Linear and rotational motors) (K.C. Tripathi, BARC, Bombay)
22. Evolution of solar active regions (K.S. Balasubramaniam, N.S.O., Sacramento Peak Obs., New Mexico, USA)
23. Changes in the concepts of space and time brought about by relativity (John Stachel, Dept. Phys., Boston Univ., USA)
24. Torsion in General Relativity– Quantum effects and some consequences (V. de Sabbata, Dept. Phys., Univ. Bologna & Ferrara, Italy)
25. Dedicated Terraflop machine - Application to many body problems (D. Sugimoto, Dept. earth and astr. sci., Univ. Tokyo, Japan)
26. Scattering and blackholes (Nils Andersson, Univ. Wales, Cardiff, UK)
27. Integrated photometric parameters of star clusters (B.C. Bhatt, UPSO, Naini Tal)
28. Recent results from IR camera (M. Ueno, Dept. earth sci. astr., Univ. Tokyo, Japan)
29. Centrifugal force reversal in general relativity (A.R. Prasanna, PRL, Ahmedabad)
30. Raman ripple lasers (R.V. Pratap, Dept Phys., Cochin Univ.)
31. Many-body theory and its applications to molecular systems (D. Mukerjee, Indian Association for the Cultivation of Science, Jadavpur, Calcutta)
32. T.G. Cowling and the early days of stellar structure theory (L. Mestel, Univ. Sussex, UK)
33. Soft gamma ray repeaters (S.R. Kulkarni, CALTECH, USA)
34. Evolution of galactic magnetic fields (B.P. Pandey, IPR, Ahmedabad)

Editors: T.P. Prabhu & A.K. Pati
Editorial Assistant: Sandra Rajiva
Published by the editors on behalf of the Director, Indian Institute of Astrophysics, Bangalore 560034.

Newsletter
Quarterly Newsletter of the Indian Institute of Astrophysics
Vol. 9, No. 1–2, April 1994

To:

Indian Institute of Astrophysics
Bangalore 560034