KHAGOL खगोल

IUCAA

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Science Day at IUCAA
27-28 February 2000

The annual National Science Day was celebrated at IUCAA on February 27-28, 2000. On Sunday 27th, the Centre was kept open to the general public, and special displays were set up describing the research activities of IUCAA, and other exciting new discoveries in Astrophysics. Visitors could also meet many of the research community of IUCAA. On Monday 28th, a Science Festival was held which included various competitions for high school students. On both evenings, a series of telescopes were set up for night-sky viewing for members of the public.

The Open House for the Public

About five thousand visitors attended IUCAA's Open House on Sunday, February 27 from 10 a.m. to 5 p.m.

Many of the academic members (including students and visitors) of IUCAA were present during the day to discuss their research with the general public with the help of posters and displays. In the Instrumentation Laboratory, one could witness various optics demonstrations, as

Observingthe skies through telescopes made in the IUCAA Science popularization laboratory by local amateurs.

Children run around the Sun in Keplerian orbits in the Science Park on the Open Day

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well as a model of the IUCAA telescope. The staff of the Computer Centre and a few students demonstrated the working of the internet, and examples from the Astronomical Data Centre at IUCAA and the astronomical image processing that was carried out at IUCAA.

Visitors spent considerable time with the interactive outdoor exhibits in the IUCAA Science Park, where a row of additional exhibits intended for the younger visitors. were set up by the Homi Bhabha Centre (Mumbai), illustrating basic principles of physics.

Two parallel series of half-hour lectures (in English, Hindi and Marathi) were given by IUCAA scientists to capacity audiences all through the day. The lecturers found themselves surrounded by members of the audience with questions for long times outside the lecture halls. The event concluded with J.V. Narlikar's one-hour session of answering questions about the Universe from the general public, which proved to be very popular.

The library's display included an account of C. V. Raman's work, which is commemorated by the National Science Day each year. Video films on astronomy and space programmes were also shown at yet another location.

From seven in the evening till midnight, hundreds of visitors viewed Saturn, Jupiter and other objects of astronomical interest, like the Orion nebula, through a row of six and eight-inch telescopes, set up by IUCAA members, with the help of members of the Jyotirvidya Parisanstha, Pune. Almost all these telescopes had been made by various amateur astronomers at IUCAA as part of our year-long workshops in mirror-grinding and telescope making.

A competitor in the Science Drawing contest in action

Demonstrations of basic physical laws for the public by high school students

The Inter-School Science Festival

The Science Festival on Monday 28th consisted of several inter-school science competitions for students up to Class X. About 450 students from 76 schools in the Greater Pune area (English, Marathi and Hindi mediums) participated in the Science Quiz, Essay (English and Marathi) and Drawing competitions on scientific themes. In addition, there was a science crossword contest for the teachers who had accompanied the students.

One student from each school took part in the Drawing competition. The first and second prizes were awarded respectively to Vrishali Talwalkar (N. M. V. Girls' High School) and Manas Marathe (Vidya Bhavan) for their portrayal of the working of mathematics in nature. (The drawings are reproduced in page 4.)

Girija Ranade (Abhinava Vidyalaya) won the first prize in the English essay competition for her account of living in a world with two stars, while Noopur Singhal (Rewachand Bhojwani Academy) and Aditya V. Bidikar (Kalmadi Shamrao High School) shared the second prize for their imaginative account of what would have happened if mankind had evolved as aquatic beings. Ashwin Pundalik (M.E.S. Boys' High School) and Sudheer S. Khandelwal (Vimlabai Garware Prashala) shared the second prize for the Marathi essay competition. No first prize was awarded for Marathi essay Competition.

In the qualifying round of the Science Quiz, each of the 75 teams had to answer 25 short questions in physics, astronomy, mathematics, chemistry and biology. In this event, each school was represented by a team of three students. Five teams were chosen to compete in the final round of the Science Quiz, which took place in the afternoon of the same day, in the Chandrasekhar Auditorium, in the presence of a capacity crowd. The team from Vikhe Patil Memorial School was the clear winner of the first prize and trophy for Quiz, with St. Ursula and St. Vincent winning the second and third places respectively.

The trophy for the best overall performance (the N.C.Rana Memorial Trophy) was won by the Vikhe Patil Memorial School. While the winning schools get to keep the trophies for the year, the individual winners are awarded book tokens as prizes. J V Narlikar gave away the prizes.

PMC Donation for the IUCAA Science Park

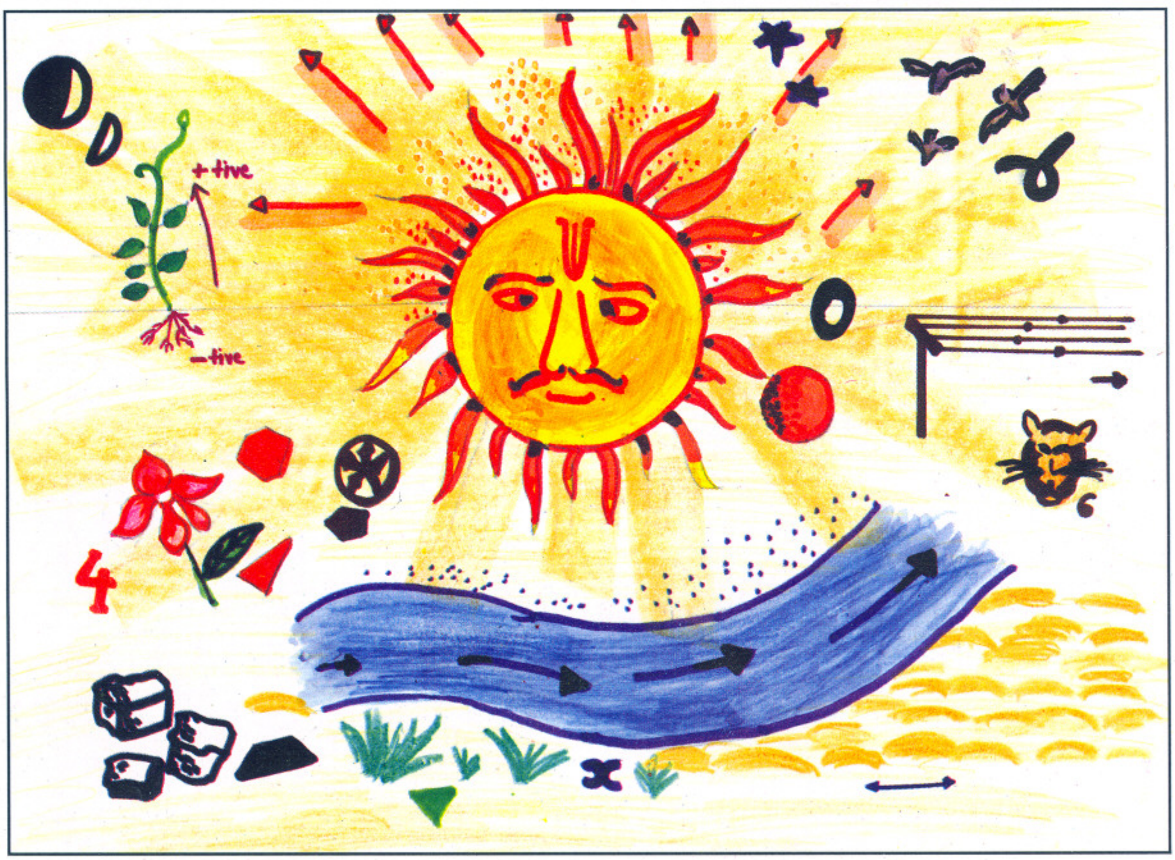
On the National Science Day, the Mayor of City, Mr. Dattatraya M. Gaikwad visited IUCAA and made a handsome donation of Rs 5 lakhs on behalf of the Pune Municipal Corporation. This is a recognition by Pune City of IUCAA's efforts at science popularization.

Mayor Handing over the cheque to the Director.

Seen in the picture are from left to right P.N. Tapikar, Personal Secretary to the Mayor, J.V. Narlikar, Director, IUCAA, Somak Raychoudhury, Chairman Science Popularisation Committee, Arun Dhimdhime, Chairman, Standing Committee (PMC), Dattatray M. Gaikwad, Mayor, Pune and Yeshwant Khaire, Garden Superintendant (PMC).

Prize-winning Drawings of the Science Day Drawing Competition.

Mathematics in Nature by Vrishali Talwalkar - First Prize



Mathematics in Nature by Manas Marathe - Second Prize.

Origin of Large Scale Galactic Magnetic Fields

Introduction

Magnetic fields are ubiquitous to astronomical systems. The nature of galactic magnetic fields can be inferred by mapping the synchrotron radio emission of nearby galaxies. These observations reveal [1] that spiral galaxies have fields of order few microgauss to tens of microgauss. Unlike in the case of the earth, where the field is largely an ordered field, the galactic field has both an ordered component and a fluctuating component, both of comparable strengths. The ordered fields are coherent on scales of several kpc. In disk galaxies like M51 and NGC 6946, they are also highly correlated (or anti-correlated) with the optical spiral arms. The origin of such large-scale magnetic fields in galaxies remains an enigma and presents a challenging theoretical problem, to which this resource summary is mainly devoted.
A popular idea is that the observed large-scale galactic fields arise due to dynamo amplification of a weak but nonzero seed field. If the galactic dynamo can operate efficiently to exponentiate the field by a factor ~ 30, then a seed field of order $\sim 10^{-19}G$, would suffice to produce microgauss strength fields. The origin of even such a small seed field needs some physical explanation, the operation of a cosmic battery effect, which produces currents from initially zero currents. We first discuss below a few concepts of MHD needed to understand these processes, before turning to galactic batteries and dynamos.

Basic Magneto Hydrodynamics (MHD)

The relevant equations for the electromagnetic fields are basically Maxwell equations with the displacement current neglected, and supplemented by the non-relativistic form of Ohm's law, that the current density $\mathbf{J} = \sigma[\mathbf{E}+(\mathbf{v}\times\mathbf{B})/c]$. Here $\mathbf{B}$, $\mathbf{E}$ are the magnetic and electric fields, $\mathbf{v}$ the fluid velocity and σ the conductivity [2]. The evolution of the magnetic field is then governed by the induction equation

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{v} \times \mathbf{B}) + \eta \nabla^2 \mathbf{B}, \qquad (1)$$

where $\eta = c^2/(4\pi\sigma)$ is the resistivity. If $\mathbf{v} = 0$, the equation reduces to the diffusion equation and describes resistive field decay. If $\eta \rightarrow 0$ the magnetic flux through any area in the fluid is conserved during the motion of the fluid. The presence of a finite resistivity allows for diffusion and a violation of such 'flux freezing'. The magnetic Reynolds number (MRN) $R_m = vL/\eta$ measures the relative importance of flux freezing versus resistive diffusion. Here v and L are typical velocity and length scales of the fluid motions. In most astrophysical contexts flux freezing greatly dominates over diffusion, with $R_m >> 1$, and this aids amplification of magnetic fields. At the same time, a non-zero η is essential for the field to undergo permanent changes by say, reconnection.
$\mathbf{B} = 0$ is a perfectly valid solution of the induction equation. So there would be no magnetic field generated if one were to start with a zero magnetic field. The universe probably did not start with an initial magnetic field. One, therefore, needs some way of violating the induction equation and produce a cosmic battery effect, to drive currents from a state with initially no current.

Cosmic Batteries

Most astrophysical batteries (cf. [3]) use the fact that positively and negatively charged particles in a charge-neutral universe do not have identical properties. For example, the masses of electrons are much smaller than that of ions in any ionised plasma. One effect of this mass difference is that, for a given pressure gradient of the gas the electrons tend to be accelerated much more than the ions. This leads in general to an electric field, which couples back positive and negative charges, of the form $\mathbf{E}_T = -\nabla p_e/en_e$, where p_e and n_e are the electron pressure and number density, respectively. If such a thermally generated electric field has a curl, then by Faradays law of induction, a magnetic field can grow. Taking $p_e = n_e kT$ with T, the electron temperature, we have $\nabla \times \mathbf{E}_T = (ck/e)(\nabla n_e/n_e) \times \nabla T$. So $\mathbf{E}_T$ has a curl only if the density and temperature gradients are not parallel to each other. The resulting battery effect, known as the Biermann battery, was first proposed as a mechanism for thermal generation of stellar magnetic fields [4].

The Biermann battery can also lead to the thermal generation of seed fields in cosmic ionisation fronts [5], which are produced when the first ultra violet photon sources, like quasars, turn on to ionise the intergalactic medium (IGM). The temperature gradient is normal to the ionisation front. However, a density gradient can arise in a different direction, if the ionisation front is sweeping across arbitrarily laid down density fluctuations, associated with protogalaxies/clusters. This results in thermally generated electric field with a curl, and magnetic fields coherent on galactic scales, with $B \sim 3\times10^{-20}G$. Indeed the whole of the IGM is seeded with small magnetic fields. The Biermann battery has also been invoked to generate seed magnetic fields during the collapse to form galaxies [6].

Larger seed magnetic fields can arise if we combine some form of dynamo action with the battery effect. For example, if stellar dynamos work efficiently, and some stars blow out as supernovae, then they can seed the interstellar medium with significant magnetic fields [3]. Alternatively, galactic turbulence can itself lead to a small-scale dynamo (see below) and provide a larger seed for the large-scale galactic dynamo.

There have also been attempts to produce primordial magnetic fields in the early universe in phase transitions or during inflation [7]. However, the correlation scale of the field generated in a phase transition is limited by the Hubble radius at that time. So even if a significant fraction of the energy density of the universe were to go into magnetic fields, the field averaged over galactic dimensions turns out to be extremely small. It is possible to produce a field with a larger correlation length at an inflationary era. However, because of the conformal invariance of the electromagnetic action, it turns out that the resulting fields are very tiny. Only models which break this invariance in some way are able to produce a significant magnetic field.

It is fair to say at present that most seed field generation mechanisms fall far short of producing large-scale correlated fields at the micro-gauss level. One does need some form of large-scale dynamo action to explain the observed galactic fields.

The large-scale galactic dynamo

Early works on galactic dynamos [1,2] were modeled after parallel theories of dynamos in the earth and the sun. Disk galaxies are differentially rotating systems. Also, the magnetic flux is, to a large extent, frozen into the fluid. So any radial component of the magnetic field will be efficiently wound up and amplified to produce a toroidal (ϕ-) component. But this results in only a linear amplification of the field. To obtain the observed galactic fields starting from small seed fields, one should find a way to re-generate the radial component from the toroidal one. If this can be done, the field can grow exponentially and one has a dynamo.

A mechanism to produce the radial field from the toroidal field was invented by Parker [8]. The essential feature is to invoke the effects of cyclonic turbulence in the galactic gas. The interstellar medium (ISM) is assumed to be turbulent, due to, for example, the effect of supernovae randomly going off in different regions. In a rotating, stratified (in density and pressure) medium like a disk galaxy, such turbulence becomes cyclonic and acquires a net helicity. Helical motions of the galactic gas perpendicular to the disk can draw out the toroidal field into a loop, which looks like a *twisted* Ω. Such a loop is connected to a current and because of the twist, this current has a component parallel to the original field. If the motions have a non-zero net helicity, then the random current components parallel to the field add up coherently. A toroidal current can then result from the toroidal field. Hence, poloidal fields can be generated from toroidal ones.

We all have an intutive idea of what turbulent fluid motions do to a scalar field "frozen" into the fluid like say, smoke. The random walk associated with the turbulence leads to an enhanced turbulent diffusion, over and above microscopic diffusion. But for 'frozen' magnetic fields, the induction equation has terms which not only imply a body transport due to the random motions ($\mathbf{v}.\nabla\mathbf{B}$), but also a term $\mathbf{B}.\nabla\mathbf{v}$, which describes the generation of magnetic fields due to velocity shear. This qualitative difference between magnetic fields and smoke leads to an additional effect, in helical turbulence, traditionally called the alpha effect, which aids the generation of magnetic fields.

Quantitatively, the action of the turbulent velocity field $\mathbf{v}_T$, on the magnetic field, the $(\mathbf{v} \times \mathbf{B})$ term leads to an extra contribution to the *mean* electric field of the form $-c\mathbf{E}_0 = \alpha \mathbf{B}_0 - \eta_T \nabla \times \mathbf{B}_0$. For isotropic, and homogeneous turbulence, α depends on the helical part of the turbulent velocity correlation function, while η_T is the turbulent diffusion and depends on the non-helical part of the turbulence. Both depend crucially on the diffusive (random-walk) property of fluid motion. If due to some reason (see below) the fluid motion becomes wavelike, then the alpha effect and turbulent diffusion will be suppressed.

The induction equation for the mean field with the extra turbulent contributions, can have exponentially growing solutions. While the α-effect is crucial for regeneration of poloidal from toroidal fields, the turbulent diffusion turns out to be also essential for allowing changes in the mean field flux. Further, in galaxies, differential rotation (the Ω effect) is dominant in producing toroidal from radial fields. The growth rates of the galactic 'α-Ω dynamo', are typically a few times the rotation time scales, of order 10^9 yr. Modulations of α, and η_T, due to enhanced turbulence along spiral arms, can also lead to large-scale fields, correlated with the optical spirals [9].

In deriving the mean-field equation, the turbulent velocities have been assumed to be unaffected by the Lorentz forces due to the magnetic field. However, this does not turn out to be valid due to the more rapid build up of magnetic noise compared to the mean field.

The small-scale dynamo and magnetic noise problem

In incompressible turbulence, fluid particles random-walk away from each other. This leads to stretching of the field lines attached to these particles, and an exponential increase of field strength. The stretching will also be accompanied by the field being squeezed into smaller and smaller volumes. If for the moment one ignores Lorentz forces, then the squeezing into small volumes stops only when diffusive scales are reached. Typically the field can be thought of as being in flux ropes, curved on the eddy scale, say L, and a thickness of order the diffusive scale, say r_d (assuming only a single scale eddy is present). At this stage, the energy input into the magnetic field due to random stretching would be comparable to the energy loss in diffusion. This gives $vB/L \sim \eta B/r_d^2$, implying $r_d \sim L/R_m^{1/2}$. What happens further (whether growth or diffusion wins out), can only be decided by a more quantitative treatment of the problem.

A rigorous analysis of small-scale field dynamics, was first worked out by Kazantsev, and elaborated extensively by many authors [10,11], for the simple case, where the turbulence was assumed to have a delta function correlation in time. It turns out that, a small-scale dynamo (SSD) can operate under fairly weak conditions; that the MRN associated with the turbulent motions be greater than a critical value $R_c \sim 100$. For $R_m > R_c$, the small-scale dynamo exponentiates the small-scale field on an Eddy-turn over time, $\tau = L/v \sim 10^7$ yr. (Here we have taken $L \sim 100$ pc, and a velocity scale $v \sim 10$ km s^{-1}.) This is much shorter than the time scale $\sim 10^9$ yr for mean field growth. The magnetic field is then rapidly dominated by the fluctuating component, before the mean field has grown appreciably. If the energy in the small-scale component grows to equipartition with the turbulent energy density, the turbulence could become more wavelike 'Alfvén' turbulence, than an eddy like fluid turbulence, suppressing α, η_T and hence the mean-field growth. How does the galaxy escape this predicament?

Saturation of the small-scale dynamo

To answer this question, it is crucial to find out how the small-scale dynamo saturates. We have argued that the small scale field saturates as a 'can of worms' with peak fields being limited by nonlinear effects to values of order or slightly larger than equipartition fields, but with most of the space having much smaller fields. Then the average energy density of the saturated small-scale dynamo generated field is still sub-equipartition, since it does not fill the volume. In this case, Lorentz forces due to the small-scale field will be too weak to make the turbulence into wave-like motions. The diffusive effects like α and η_T, will be preserved. We have given explicit realisation of the above idea, in some model examples [11].

Numerical simulations of dynamo action due to mirror-symmetric turbulence or convection have also hinted at a saturated state of SSD as described above [12]. Such simulations, are however, limited by the MRN they can achieve. There have also been MHD simulations of the SSD in fourier space, adopting some form of closure approximation [13]. They have indicated that the small-scale field could saturate at sub-equipartition levels. The simulations of Pouquet *et al.* and Meneguzzi *et al.*, further considered the effect of helicity in the turbulence, and found that large-scale fields can grow even in the presence of significant small-scale fields. However, why all this happens and the relation of the fourier space to the real space calculations is not at present clear. Another important issue which is just beginning to be addressed [14] is the calculation of α (or η_T) in the presence of significant small-scale fields. It is also important to understand how effective is the reconnection, which will be ultimately be neccessary to smooth the magnetic fields [15].

The helical, turbulent, α-Ω dynamo still seems to be the best bet for explaining large-scale galactic fields. However, the details of its workings in the non-linear regime and in the presence of significant small-scale fields remain an unfinished business. This will be the problem to solve if one wants to ultimately understand the origin of large-scale galactic magnetism.

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Launch Pads for the New Millennium

The Third Millennium A.D. begins on January 1, 2001. Having described the progress of astronomy upto the present, the last year of the Second Millennium, let us speculate on what issues will provide the parsecstones for the future.

In the 28th Parsecstone, we promised a glimpse into the surveys of the Solar System provided by spacecrafts launched from the Earth. The 1960s decade saw the start of this adventure. With the exception of the Moon, where man landed for the first time on July 20,1969 through the historic Apollo 11 mission, manned landings are still well into the future.

Although the American and Russian space missions have sent several spacecrafts around the planets Mercury, Venus, Jupiter and Saturn also, Mars provides the greatest attraction. The issue of whether life exists on Mars , or existed in the past is still to be settled. The two Viking Spacecrafts landed on Mars in 1976 and carried out studies of the Martian soil for any sign of microbial life. The experiments were inconclusive. The interest was, however, revived in 1996, by the possible evidence of fossilized life found in a meteorite believed to be of Martian origin. Although the evidence is contested, it is agreed that Mars needs to be more carefully studied and NASA has begun a programme of periodic flights to the planet of which the Pathfinder mission launched in December 1996, was the first one. It is expected that humans may eventually land on Mars within two to three decades.

Another parsecstone will be reached when a space based gravitational wave antenna starts functioning and detecting gravitational radiation. A proposal (LISA: Laser Interferometric Space Antenna) is already on the drawing board and more will no doubt be proposed as the detector technology improves. In any case, the first positive detection of a gravitational wave signal will be a major achievement for technology.

Our understanding of the formation and evolution of galaxies is still in a rudimentary state, much like our understanding of stellar structure and evolution was at the beginning of the twentieth century. The parsecstone marking this understanding may well form the highlight of the twentyfirst century astrophysics.

As shown by the trend of the last two decades, technological advances will generate new tools for the astronomer, and many studies across all wavelengths of the electromagnetic radiation, hitherto considered impossible, may become reality. Contrary to the general expectation that deeper and more detailed studies will solve all questions is, however, unwarranted. Our present questions may be solved, but new ones may take their place.

What about cosmology? Despite the considerable optimism that exists in the big bang camp that the problem of the origin of the universe will be solved in the twentyfirst century (- some believe that this will happen in the first decade), my own personal expectation is that better and more sophisticated technology will reveal the as yet unknown details of the structure of the universe, with the result that cosmologists may have to rework their models. Inputs about the nature and extent of dark matter, redshift surveys, studies of anomalous redshift cases, gravitational lensing, extragalactic supernovae, gamma ray burst sources, etc., will provide challenges whose successful solutions will mark new parsecstones. But I doubt that we will ever understand the essential features of the universe in full totality.

Finally, will the twentyfirst century see the terrestrials discovering that they are not alone in the universe? If that happens, that will be the most important parsecstone in the history of mankind.

Workshop on Quasar Spectroscopy

Participants of the workshop on Quasar Spectroscopy

A workshop on Quasar Spectroscopy was held in IUCAA during January 21 - 23, 2000. Topics covered in this workshop include, multiwavelength study of quasars and AGN, models of continuum emission, chemical enrichment, quasar formation and the intergalactic medium. Talks were given by M. Burbidge (University of California, San Diego), Suzy Collin (Meudon Observatory), Jayaram Chengalur (NCRA), U. C. Joshi (PRL), Ajit Kembhavi (IUCAA), Pushpa Khare (Utkal Univ.), Gopal Krishna (NCRA), T. Padmanabhan (IUCAA), P. Shastri (IIA, Bangalore), R. Srianand (IUCAA) and Yogesh Wadadekar (IUCAA).

International Conference for Science Communicators (ICSC 2000)

A meeting for science communicators was organized at IUCAA by the National Centre for Science Communicators during January 28-30, 2000 in which 200 Science writers, journalists and popularizers from India and abroad participated. The main discussion sessions were on the social implications of science and technology, resources for science communicators, the financial viability of science publication in the popular media, and the networking of communicators at the national and international levels. The invited speakers were E. Candotti (Brazil, Kalinga awardee 1998), M. E. Addy (Ghana, Kalinga awardee 1999), N. K. Sehgal and J. V. Narlikar (earlier Kalinga awardees), J.-C. Pecker (France), M. Burbidge (USA), Zaffarullah Choudhary (Bangladesh), V. G. Bhide, Saroj Ghose, Bal Phondke and Sam Pitroda (all from India). Several of the evening talks were open to the general public.

Visitors during January - March 2000

S. Bhavsar, D. Malquori, P.S. Parihar, S.K. Sahay, H. Khosroshahi, M.Azimlu, S. Barway, R.P. Bambah, E. Saikia, S.K. Banerjee, F. Nasseri, P.P. Hallan, M. Sami, A.K. Sen, K.S. Govinder, B.S. Sathyaprakash, R. Maartens, Rajashree Thakur, G. Horwitz, J. Chaudhury, A. Rawat, T. Ghosh, Z. Ahsan, N. Joharapurkar, D. Seetharam, B. Medhi, Sanath Kumar, R.S. Geetha, B.K.Shukla, J. Bicak, M. Burbidge, P. Shastri, M.N. Anandaram, P. Kharb, A.Chaitra, D. Lal, V. Doddamani, S. Colin, S. Ramadurai, S. Vadawale, P. Khare, D. Narasimha, K.S. Baliyan, U.C. Joshi, A.C. Gupta, P.S. Naik, R.R. Reddy, Y. Nazeer Ahmed, P. Nagabhushana Swamy, B.B. Walwadkar, J.C. Pecker, A. Sil, Ch.V. Sastry, J. Touma, M.S. Khan, N. Iqbal, S.D. Maharaj, S. Chakravarti, M.L. Kurtadikar, J.J. Rawal, R.G. Vishwakarma, C.D. Ravikumar, M.N. Vinoj, V. Bhandarkar, B. Engavale, N. Arora, D. Kadam, G. Palkar, S. Pawar, V.H. Kulkarni, Shankarnarayan, P.C.Bafna, J. Agrawal, M. Khan, S.S. De, Shibu Mathew, S. Datta, I.K. Mukherjee, A.D. Ghaisas, R.S. Patwardhan, P. Navale, B.L. Walvi, S. Pathare, A. Ashtekar, T.C. Phukon, K. Srinivasan, N.Mukunda, T. Mukai, A. Kamei, D.B. Vaidya and D. Lynden-Bell.

Seminars

25.1.2000 Jiri Bicak *on* Radiative Spacetimes; 17.2.2000 Tarun Deep Saini *on* A new method of mass reconstruction from shear; 17.2.2000 Yogesh Wadadekar *on* Optical studies of VLA first survey sources; 21.2.2000 Shibu K. Mathew *on* Solar Magnetic Field Measurements Using Voltage Tunable FP Etalon; 21.3.2000 Tadashi Mukai *on* Observation of Interplanetary Dust Bands by CCD Camera and 22.3.2000 Akihide Kamei *on* Laboratory Measurements of Laser Light Scattering by Rough Surface 27.3.2000.

Colloquium

24.1.2000 Jiri Bicak *on* Relativistic Disks: Exact Models.

Visitors Expected

April: K. Indulekha, M.G. University, Kottayam; J. Dey, Presidency College, Calcutta; S. Ray, Presidency College, Calcutta; K. Jotania, Xavier's College, Ahmedabad; P. Saha, Queen Mary & Westfield College, UK; Palash Pal, SINP, Calcutta; G.P. Singh, VRCE, Nagpur; C.V. Vishveshwara,IIA, Bangalore; M.L. Kurtadikar, JES College, Jalna; R. Tikekar, Sardar Patel University, Vallabh Vidyanagar; D. Lohiya, University of Delhi; N. Rooprai, S.G.T.B. Khalsa College, Delhi; S.N. Biswas, W. Bengal; A. Sarma, Assam.

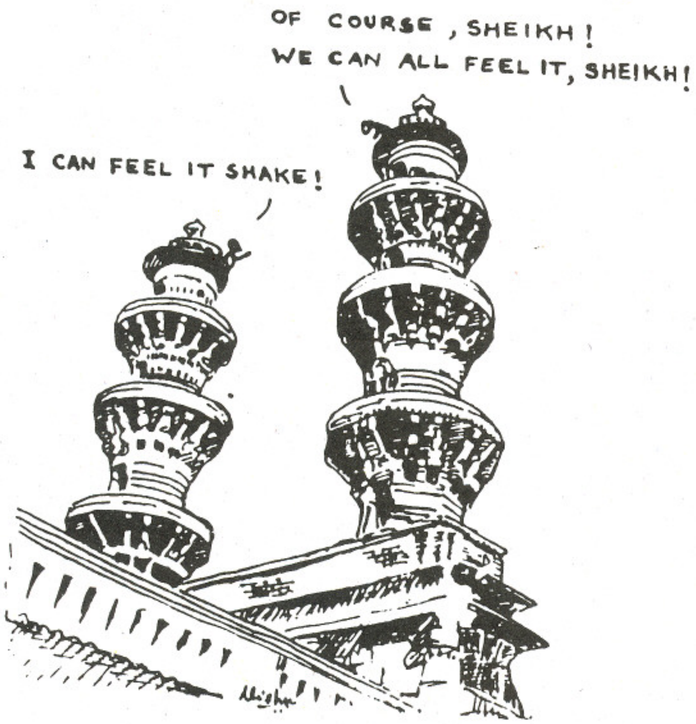
May: R. Saraykar, Nagpur University; Y. Narasimha Murthy, Sri Sai Baba College, Anantpur; B. Chakraborty, Jadavpur University; A. Pradhan, Hindu Degree College, Ghazipur; S.P. Bhatnagar, Bhavnagar University; K. Desikan, M.O.P. Vaishnav College for Women, Chennai; S. Chaudhuri, Gushkara Mahavidyalaya, Burdwan; R. Bali, University of Rajasthan, Jaipur; Chanda Jog, IISc., Bangalore; S. Chakraborty, Jadavpur Unviersity; P.S. Naik, Gulbarga University; M. Khan, Jadavpur University; R. Sharma, Meerut College; P. Agarwal, Meerut College; K. Rama Gopal, Sri Krishnadevaraya Unviersity, Anantapur; P. Abdul Azeem, Sri Krishnadevaraya University, Anantapur; R. Ramakrishna Reddy, Sri Krishnadevaraya Univeristy, Anantapur; L.M. Saha, Zakir Husain College, Delhi; T.P. Sarma, Zakir Husain College, Delhi; K.G. Chhaya, Govt. Science College, Rajkot.

June: P.C. Vinodkumar, Sardar Patel University, Vallabh Vidyanagar; G. Prasad, S.C. College, Ballia; V.K. Gupta, University of Delhi; B. Ishwar, B.R.A. Bihar University, Muzaffarpur; L. Prasad, M.B.Govt. P.G. College, Nainital; V.O. Thomas, M.S. University, Vadodara; R.S. Kaushal, University of Delhi; Udit Narain, Meerut College; D.K. Chakraborty, Pt. Ravishankar Shukla University, Raipur; V.C. Kuriakose, CUSAT, Kochi; S. Singh, Deshbandhu College, Delhi; B.K. Sinha, S.C. College, Ballia.

Congratulations!

...to **S.V. Dhurandhar,** for the Principal V.K. Joag Best Teacher Award of the University of Pune.

The Shaking Minarets of Ahmedabad



The famous Shaking Minarets of Ahmedabad built around the middle of the fifteenth century, consist of two lofty towers with a connecting bridge forming a resonating system. It is a little known fact that the Minarets were the first dipole antenna ever designed and constructed to detect gravitational radiation. Vibrations of the minars induced by gravity waves were picked up by a highly sensitive thin-skinned nobleman belonging to the court of the ruling Ahmedshah dynasty and transmitted orally to an equally sensitive receiver. The antenna was most effectively shielded by soldiers who wielded not only shields but also swords. They eliminated all sources of noise, both white and coloured, without racial discrimination. Data were analysed using abaci placed perfectly parallel to one another, a procedure that heralded parallel-computing. Although the dipole antennae like the Shaking Minarets firmly established the existence of gravity waves, they were abandoned in favour of quadrupole antennae with four minars such as the Charminar in Hyderabad and the Taj Mahal in Agra. The results of these observations were never made public on account of cuts in royal funding, court intrigues, harem politics and charging pages. Here was another authentic case in unrecorded history of a major discovery perishing because of not publishing. (For the first one see Khagol, No. 41, January 2000.)

- By courtesy of C.V. Vishveshwara

IUCAA Preprints

Listed below are the IUCAA preprints released during January - March 2000. These can be obtained from the Librarian, IUCAA (library@iucaa.ernet.in).

Habib G. Khosroshahi, **Yogesh Wadadekar**, **Ajit Kembhavi** and **Bahram Mobasher**, A near infrared photometric plane for ellipticals and bulges of spirals, IUCAA-1/2000; **Sukanta Bose**, **Archana Pai** and **Sanjeev V. Dhurandhar**, Detection of gravitational waves from inspiraling compact binaries using a network of interferometric detectors, IUCAA-2/2000; **Zafar Ahsan**, On the symmetry of the perfect fluid space-times, IUCAA-3/2000; **E. Chassande-Mottin** and **S. Dhurandhar**, Adaptive filtering techniques for interferometric data preparation: removal of long-term sinusoidal signals and oscillatory transients, IUCAA-4/2000; **K.R. Muller**, **G. Wegner**, **S. Raychaudhury** and **W. Freudling** on Fundamental plane distances to early-type field galaxies in the South Equatorial Strip, IUCAA-5/2000; **D.B. Lortan**, **S.D. Maharaj** and **N.K. Dadhich**, Inheriting geodesic flows, IUCAA-6/2000; **Tarun Deep Saini** and **Somak Raychaudhury**, A lens mapping algorithm for weak lensing, IUCAA-7/2000; **Tarun Deep Saini**, **Somak Raychaudhury** and **Yuri A. Shchekinov**, Observing high-redshift Supernovae in lensed galaxies, IUCAA-8/2000; **Naresh Dadhich**, Spherically symmetric empty space and its dual in general relativity, IUCAA-9/2000; **Naresh Dadhich**, On product spacetime with 2-sphere of constant curvature, IUCAA-10/2000; **Niranjan Sambhus** and **S. Sridhar**, The pattern speed of the nuclear disk of M31 using a variant of the Tremaine-Weinberg method, IUCAA-11/2000 and **S. Shankaranarayanan** and **T. Padmanabhan**, Hypothesis of path integral duality III: Applications to QED, IUCAA-12/2000.

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