

M. S. N. Reddy (S.V. University, Tirupati) focused on challenges of health care for the elderly. Indira Jai Prakash (Bangalore University, Bangalore) gave an account of the positive approaches that are likely to be taken for the care of the elderly in the new millennium.

One of the scientific sessions dealt specially with Ayurveda and aging. Ram Harsh Singh (Institute of Medical Sciences, BHU, Varanasi) and other experts from different parts of the country discussed about the Ayurvedic approaches to maintain good health at old age. The deliberations mainly focused on the concept of aging and its care in ancient Indian medicine. Hemant Singh (Central Drug Research Institute,

Lucknow) spoke about Brahmi and its function as a memory-enhancing drug.

Besides regular sessions, there were two special round table discussion sessions. In one session organized by Aparjit Dey (AIIMS, New Delhi), participants discussed about the training and education of medical professionals and caregivers to take care of the elderly population. I. S. Gambhir (Institute of Medical Sciences, BHU, Varanasi) informed about the medical facilities available for the elderly in the hospital. Ake Rundgren and Ove Dehlin (Malmo University, Sweden) gave an account of education and research in geriatrics and gerontology in Sweden. Another session organized by P. V. Ramamurti (S.V. University, Tirupati) dealt with the

issue of 'National Policy for Older Persons'. The outcome of the discussions was recorded in the form of recommendations and have been communicated to the Government of India for consideration and implementation.

To sum up, the symposium was academically highly fruitful and useful to know how to lead a successful and healthy life at old age. The symposium was beneficial for scientists, social workers, policy planners as well as the common man.

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RESEARCH NEWS

It takes two to tango: New quasicrystals and novel superconductors

S. Ranganathan

Most elements are metallic. The remaining ones can be cajoled by suitable application of pressure or temperature to become metallic. The utility of metals is enhanced, when they are alloyed with each other. Contrary to popular belief, alloyed pleasures are many. The alloying of two elements leads to a binary alloy, as man found at the dawn of civilization by alloying copper with tin and iron with carbon in an inadvertent fashion. Since then, many alloys have been made with multi-components leading to ternary, quaternary, quinary and higher order alloys. We have over 3000 combinations possible for binary alloys. Their phase stability has been well documented. The combinatorial possibilities increase enormously, with over 80,000 ternary and 1,500,000 quaternary alloys. It is humanly impossible to evaluate all these systems by experiments. Yet many engineering alloys, such as the nickel base alloys used in jet engine turbine blades, con-

tain more than 12 elements. Often, metallurgists have been guided by hunches and empiricism in developing them. Modern supercomputers hold out the promise that in the not-too-distant future, all the phase diagrams may be calculated from first principles and alloys can be designed for specific applications. But till this happens, we will have to rely on serendipity.

As binary alloys have been studied for a long time, it may be assumed that there are no surprises left. But wait a minute, just at the beginning of this millennium two startling discoveries have been announced. The first relates to the discovery of a stable icosahedral quasicrystal in cadmium-ytterbium system by An Pang Tsai of the National Research Institute of Metals, Tsukuba. The second is the announcement of the discovery of a new superconductor in magnesium-boron system by Jun Akimitsu of Aoyama-Gakuin University, Tokyo at a meeting in Sendai in January

2001. It is noteworthy that both discoveries have come from Japan. Both have been reported in *Nature*^{1,2}.

Quasicrystals made their debut in 1984, when Dan Shechtman and coworkers found to their amazement crystallographically forbidden five-fold rotational symmetry in rapidly quenched aluminium-manganese alloys³. Dubbed as 'quasicrystals', they have become the most intensely pursued intermetallics during the past eighteen years, leading to over 10,000 publications. Several systems based on aluminium, gallium, titanium, zirconium, hafnium, zinc and magnesium alloys have been shown to form quasicrystals. An important finding was that several of the quasicrystals are stable, finding their rightful place in phase diagrams. Indian scientists have made several contributions to this research field. S. Ranganathan and K. Chattopadhyay discovered decagonal quasicrystals⁴ in 1985, while P. Ramachandra Rao and G. V. S. Sastry

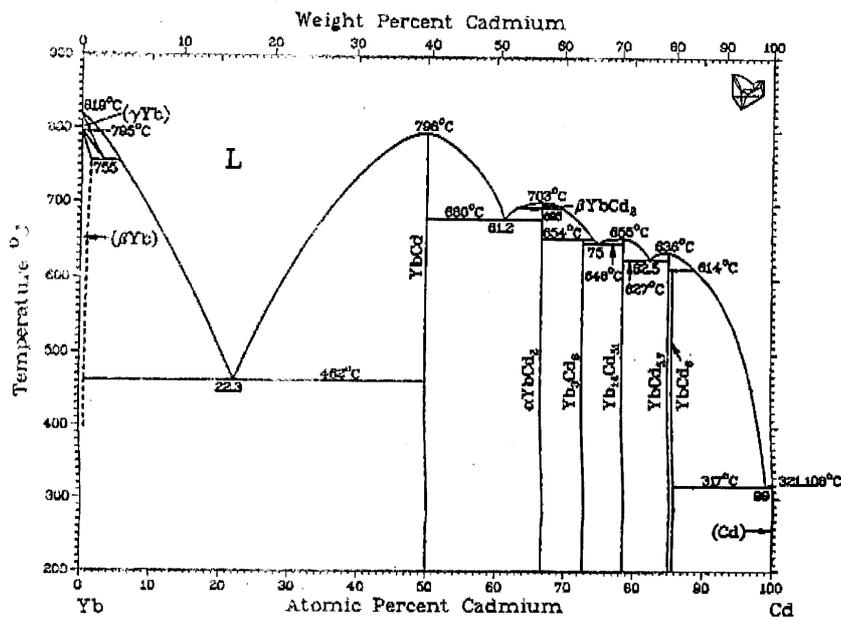


Figure 1. Equilibrium phase diagram of cadmium-ytterbium system¹².

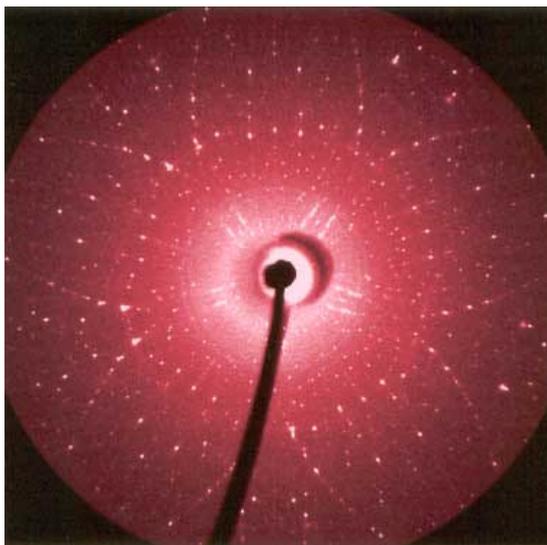


Figure 2. Transmission Laue X-ray diffraction pattern along 5-fold axis of a single quasicrystal¹. Reprinted by permission from *Nature* (2000, **408**, 537–538). Copyright (2000), Macmillan Magazines Ltd.

discovered a whole new class of quasicrystals in Mg–Zn–Al alloys⁵. Vijay Kumar identified an important approximant for decagonal quasicrystals⁶.

A problem with modelling quasicrystals was that they usually consisted of three or more elements. Thus the discovery of a stable binary quasicrystal in cadmium–ytterbium system came as a great relief. Tsai has had previous exploits to his credit such as the discov-

ery of the first stable quasicrystals in Al–Cu–Fe alloys⁷ and several new quasicrystals in Zn–Mg–RE (RE = rare earth) alloys⁸.

The discovery of the binary quasicrystal follows a fascinating trail. In 1982 E. M. Padezhnova and coworkers investigated the Mg–Y–Zn ternary system⁹. They identified the structure of one compound and left the other structure unsolved. In 1993 Z. Luo and coworkers identified this unknown

structure to be an icosahedral quasicrystal¹⁰. Tsai extended this to a whole set of Zn–Mg–RE systems with RE = Gd, Tb, Dy, Ho and Er. Thus, zinc-based large single quasicrystals with extraordinary perfection came to be studied in an intensive fashion. Since Zn and Cd are homologous elements, it is natural to substitute Zn with Cd. This idea, which seems self-evident, took seven years before it was actually tried. Tsai and coworkers, in 2000, produced Cd–Mg–RE quasicrystals with as many as 11 different RE elements¹¹. They noticed that Cd–Mg–Yb formed a quasicrystal in the as cast condition. Since Cd and Mg are mutually soluble in all proportions, the thought of completely replacing Mg by Cd arose. A scrutiny of the phase diagram (Figure 1) shows that Cd and Yb have very little mutual solubility¹². The diagram is marked by a series of eutectic and peritectic reactions and a serried array of line compounds. Tsai noted that whilst Cd₆Yb crystallized with a cubic structure at just 1% away was another compound – Cd_{5.7}Yb – of unknown structure. This is like striking gold. TEM and XRD studies revealed that the unknown structure was indeed an icosahedral quasicrystal. Figure 2 shows the transmission Laue X-ray diffraction pattern along 5-fold axis of a single quasicrystal¹. From that it was just one more step to look at Cd–Ca phase diagram, which features the same two compound types to uncover yet another stable binary quasicrystal. Modelling of this structure¹ is based on the neighbouring crystalline compound Cd₆Yb (Figure 3). Even though the innermost shell is a tetrahedron and lacks icosahedral symmetry, in some way it must link up with the symmetry of quasicrystals. New challenges have arisen as a result of this remarkable experiment.

The legendary experiment in 1911 of Kammerlingh Onnes, unearthed at first the sudden disappearance of resistance, then attributed it to shorted wires and actually heralded a new and exotic behaviour of superconductivity in certain materials. From simple elements to complex intermetallic compounds, scientists were guided by the periodic table to make slow progress from a superconducting transition temperature (T_c) of 4.2 K for mercury in 1911 to 23.2 K for sputtered Nb₃Ge films in 1974. Thereafter, the race for higher

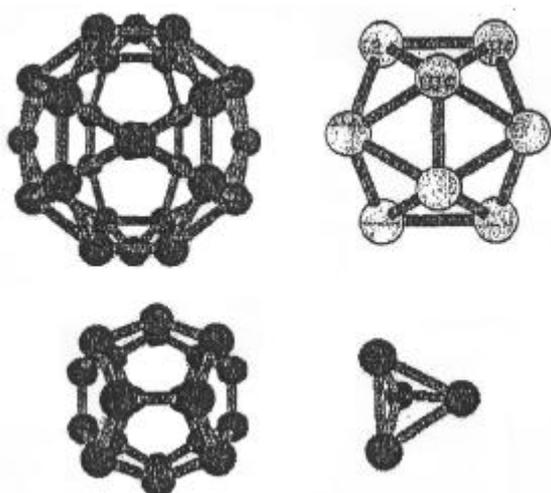


Figure 3. Successive shells of 66 atoms in $Cd_6 Yb$ crystal consisting of a tetrahedron, a dodecahedron, an icosahedron and an icosidodecahedron¹. Reprinted by permission from *Nature* (2000, **408**, 537–538). Copyright (2000), Macmillan Magazines Ltd.

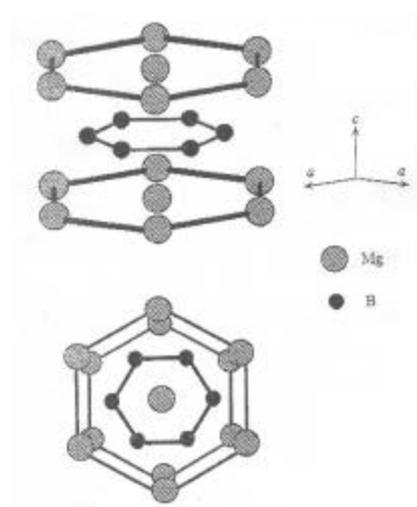


Figure 5. Crystal structure of MgB_2 (ref. 2). Reprinted by permission from *Nature* (2001, **410**, 63–64). Copyright (2001), Macmillan Magazines Ltd.

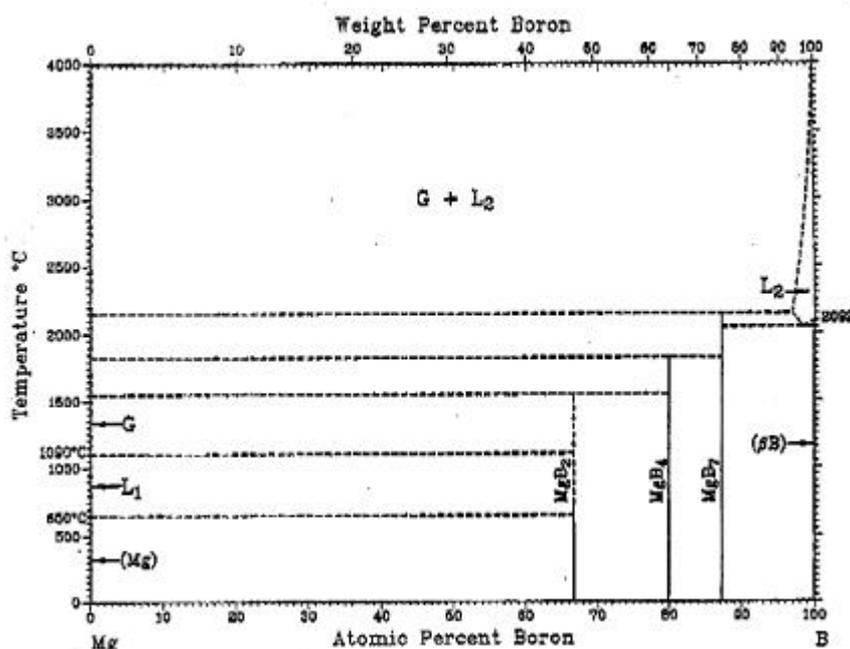


Figure 4. Equilibrium phase diagram of magnesium–boron system¹².

transition temperatures reached a plateau. Thus, the discovery of high temperature superconductivity (HTSC) twelve years later in cuprates with T_c close to 40 K by J. G. Bednorz and K. A. Mueller¹³ fuelled a race with T_c reaching beyond the boiling point of liquid nitrogen, hovering around 90 K for a while. So far, more than 150 HTSC have been found with the current record of T_c held at 134 K by $HgBa_2Ca_2Cu_3O_{8+d}$, which can be nudged up to 164 K by the application of 30 GPa pressure. This discovery

came in 1993 and this record is yet to be shattered. Indian contributions to this field are significant. Particular mention must be made to the contributions by C. N. R. Rao¹⁴, whose seminal work on transition metal oxides anticipated some of these developments.

While copper-oxide superconductors have shown very high transition temperatures, other classes of materials such as organic compounds and fullerenes are being pursued to find materials with enhanced T_c s. These include, $Cs_xRb_yC_{60}$ ($T_c \sim 33$ K) and

$Ba_{1-x}K_xBiO_3$. ($T_c \sim 30$ K). Special mention may be made of the discovery of quaternary borocarbides by R. Nagarajan and coworkers¹⁵. The highlight of this family of superconductors is the occurrence of the exotic phenomenon of coexistence of superconductivity and magnetism in some of the members.

The very recent discovery of superconductivity in MgB_2 sets a new record T_c for non-copper oxide conductors. Nagamatsu and coworkers² prepared MgB_2 from the elemental powders. The phase diagram¹² is shown in Figure 4. As in the previous phase diagram, the two components show little mutual solubility. As the melting components of the two components are widely different, gas and liquid phase equilibria dominate the diagram. Again, a number of line compounds of fixed stoichiometry are seen. Lurking among them was the incredible compound MgB_2 with a hexagonal structure ($a = 3.086 \text{ \AA}$ and $c = 3.524 \text{ \AA}$). It has three atoms in the unit cell. The boron atoms are arranged in layers with Mg layers interleaving them (Figure 5). Even though the compound has been known since 1954, no one had measured its electrical resistance at low temperatures, until now! A well-defined Meissner effect was observed at 39 K. This was also confirmed by resistivity measurements² (Figure 6). It was also confirmed that the super-

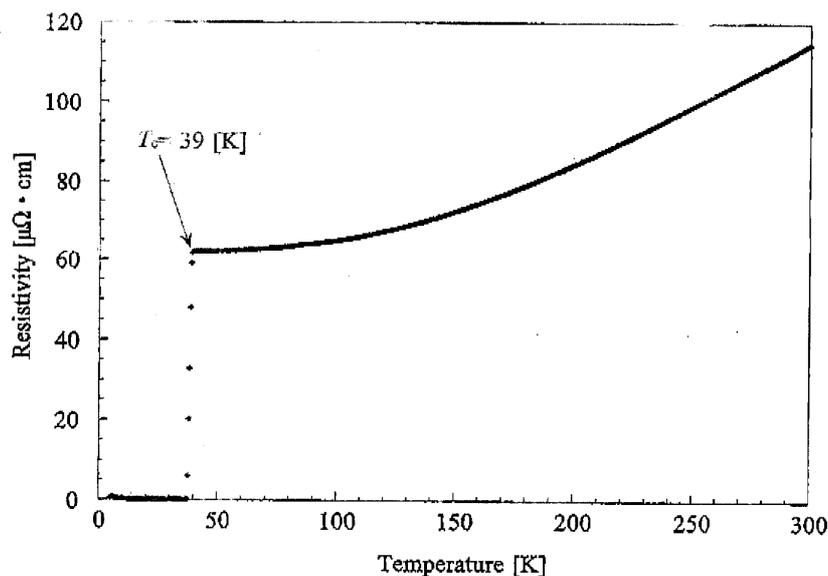


Figure 6. Temperature dependence of the resistivity of MgB₂ under zero magnetic field². Reprinted by permission from *Nature* (2001, **410**, 63–64). Copyright (2001), Macmillan Magazines Ltd.

conductivity is bulk in nature. Numerous other compounds crystallize with this structure. Whether all of them will exhibit superconductivity, some perhaps with higher transition temperatures is an open and tantalizing question.

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Random selection

Catastrophic Events, Fluids and Fault Lines

Why large earthquakes are rather rare
G. Golitsyn
Quantum, Jan/Feb. 2000, p. 4.

Beno Gutenberg and Charles Richter were interested in the relationship between the magnitude of an earthquake and the amount of energy it releases. The largest known earthquake (typically of magnitude 9 on the Richter scale) releases a million times more energy compared to the earthquake at the

threshold to damage (typically of magnitude 5 on the Richter scale). The magnitude of an earthquake is proportional to logarithm of (maximum of amplitude of Earth's motion). So, for example, when one compares a magnitude 8 earthquake to a magnitude 4 earthquake, the ground is moving 10,000 times more in the magnitude 8 earthquake compared to that in the magnitude 4 earthquake. Gutenberg and Richter were also interested in the number of earthquakes of various magnitudes M . It was noted that the number of earthquakes of magnitude M is proportional to 10^{-bM} . Although b varies

from place to place somewhat, generally it is equal to 1.

In the article under selection, Academician Golytsin deals with how 'various applications of science require knowledge of fluid flow. We will see why a large and interesting event requires a longer waiting period (expectation time) and how long one must wait (on average) to observe such an event'.

After dealing with droplets and tubes, Golytsin considers the nature of turbulence under the Earth's crust and then moves on to earthquakes *per se*. Seismologists usually express the distribution law for mean occurrence rate of