# ... or a Panglossian guile?

Belavadi and Vivek (BV) point out that the functional domain might not be along the diagonal of the morphospace limited by the diameters of corolla tube and of style as defined in my commentary[1] because (a) corolla has other structures as well in it (e.g. anther tube), and (b) there shall be a certain (minimum) threshold diameter of the nectar column in the corolla tube such that honey bee derives at least a certain amount of reward on visiting a flower. However, if we denote the vertical axis of morphospace (corresponding to corolla) as the effective diameter of the corolla available after accommodating for both (a) and (b) above, then effectively the functional domain defined and the argument thereof in my article do not change; natural selection would still shape the style to move the system to such newly defined functional domain.

Second, while I do not disagree with BV's suggestion that style could be subjected to natural selection, my caution was that one cannot be too sure. In fact one major reason for comparing their argument with the Panglossian paradigm was that they state in the abstract of their paper that 'plant facilitates pollinators to draw more nectar, by keeping the style within, and that the thickness of style may have some significance in the evolution of the system'. Till they demonstrate the role of natural selection, BV cannot escape from the pangs of the Panglossian paradigm.

K. N. GANESHAIAH

*Department of Plant Genetics and Breeding, University of Agricultural Sciences, GKVK, Bangalore 560 065, India*

NEWS

# Quasicrystals*

The past fifteen years have witnessed several fascinating discoveries in materials science. Among them the discovery of quasicrystals in 1984 by Dan Shechtman and his co-workers led to a paradigm shift in our understanding of atomic configurations in the solid state[1]. Equally remarkable is the discovery of a new allotrope of carbon by H. W. Kroto *et al.*[2] in 1985. This beautiful molecule has been christened as Buckminsterfullerene. In 1986, J. G. Bednorz and K. A. Mueller astounded the world by their announcement of a high temperature superconducting ceramic material[3]. This succession of new materials has presented the materials scientists with an embarrassment of riches. These three seminal discoveries have attracted an extraordinary effort from the scientific community. Thus we find in 1995 W. W. Mullins in his Von Hippel Award address before the Materials Research Society of the USA emphasizing them as milestones in the evolution of materials science[4]. In 1996 Alan Cottrell in the Inaugural Hirsch Lecture at Oxford University, UK described the three developments as 'surprises in materials science' and forecast future surprises[5]. In all the three areas the Indian scientists have made significant contributions. Here we report the developments in one field, namely quasicrystals, as captured in a recent conference. This conference was a continuation of the international meetings on quasicrystals, with the first five meetings being held at Les Houches (France, 1985), Beijing (China, 1987), Vista Hermosa (Mexico, 1989), St. Louis (USA, 1992) and Avignon (France, 1995). The ICQ6 was organized under the joint Chairmanship of T. Fujiwara and S. Takeuchi and sponsored by the Yamada Science Foundation, Japan (under the banner of Yamada Conference, XLVII) and supported by various societies such as the Physical Society of Japan, the Japan Institute of Metals and the Japan Society of Applied Physics. Nearly 200 delegates participated in the conference from more than twenty countries, mainly from Japan, Germany, France, China, USA and India. This time, there were five participants from India – S. Ranganathan (IISc.), U. D. Kulkarni (BARC), N. K. Mukhopadhyay (NML), Arvind Sinha (NML) and Alok Singh (IGCAR). S. Ranganathan chaired one session. The conference was divided into 19 sessions where 45 and 145 papers were presented in oral and poster sessions respectively. A night session was also organized on 28 May at the National Olympic Youth Memorial Centre for young researchers.

*Report of the Sixth International Conference on Quasicrystals (ICQ6) held in the University of Tokyo, Japan from 26 to 30 May 1997.

## Major results reported at the conference

The topics of presentation were classified into eleven categories. The topics along with the number in square bracket, indicating the number of papers in the particular topic, are as follows:

(i) Mathematical physics and generalization of crystallography [32]; (ii) Crystalline and related cluster compounds [12]; (iii) Metallurgy: Sample preparation and phase diagram [22]; (iv) Phase stability [20]; (v) Defects: Point defects, phasons, dislocations and diffusions [7]; (vi) Dynamical properties: Phonons and phasons [9]; (vii) Mechanical properties: Elastic and plastic properties [15]; (viii) Electronic properties: Optical, transport and magnetic properties [45]; (ix) Applications: Processing, coating and nanostructures [5]; (x) Structure [15]; (xi) Surface [8].

Subjectwise, the themes can be broadly grouped as synthesis, structure, stability, properties and applications. Some of the interesting issues which made the conference scientifically very illuminating and exciting, are discussed here.

## Synthesis

New decagonal phases were reported in Mg–Zn–RE (RE = rare earth elements) by An Pang Tsai's group in National Research Institute of Metals (NRIM), Japan. It is the first time that the existence of a decagonal quasicrystals in Mg–Zn base systems was established. The variation of diffraction patterns depending on composition and processing conditions was well documented in Mg–Zn–Ho system. K. H. Kuo's group in China discovered the existence of decagonal and icosahedral phases in many Ga-base systems such as, Ga–Cu–Fe, Ga–Co–Cu, Ga–V–Ni(Si) systems. They also confirmed the stability ranges of decagonal and icosahedral quasicrystals in terms of composition and temperature. In Ti-base quasicrystals, a stable icosahedral phase was found for the first time by K. F. Kelton's group (USA) in Ti–Zr–Ni system. It should be noted that earlier, stable quasicrystals were only available in Al-base and Mg-base quasicrystals but not in Ti-base quasicrystals. A new type of 1/1 rational approximant (RA) structure, which is different from $\alpha$-(Al–Mn—Si) type was also identified by them along with possible structural modelling. Previously, it was believed that RA of Ti-base quasicrystal is Mackay Icosahedral type, but in this conference it was demonstrated that the Bergman clusters are more dominant than the Mackay clusters. In Al–Fe–Cu, so far no cubic RA was reported. However, in Al–Fe–Cu–Si system, 1/1 RA structure which is similar to $\alpha$-(Al–Mn–Si) structure was presented in this conference.

## Structure

The importance of pursuing tiling theory in the context of structural solution of QC was emphasized by several authors. The issue of single tile-based generation of Penrose tiling and single point based approach of quasilattice along with coloured Penrose tiling were addressed in this conference. It may be recalled that V. Sasisekharan did pioneering work in this area in India nearly a decade ago. A five-coloured Penrose tiling was used to characterize screw dislocations in decagonal quasicrystals. Most of the efforts were devoted to investigate the structures and properties mainly of Al–Pd–Mn, Al–Fe–Cu, Al–Co–Ni and Mg–Zn–RE systems. Though the structures are not yet completely sorted out uniquely, it was realized that the higher dimensional crystallography is the more suitable and convenient way to develop the methodology towards structural solutions. The important issue which was discussed in greater depth was the structural aspects of quasicrystal, i.e. 'where are the atoms?'. A. Yamamoto's group (NRIM at Tsukuba, Japan) has demonstrated that their structural modelling compared to others yielded more satisfactory results on Al–Co–Ni decagonal phases, though the reliability factor is far from the standards of conventional crystallography. V. Elser of Cornell University presented structural modelling of Al–Pd–Mn quasicrystal based on the Bergman clusters rather than the Mackay clusters which used to be the case earlier. The discussions on these aspects have pointed out the need to pursue the structural modelling work based on other types of icosahedral clusters as well and ultimate success would be tested through R-factor. However, the approach seems to be worth pursuing to solve the structure uniquely. It is felt that coherent and consolidated efforts must be aimed at the structural solution and the responsibility of coordinating the efforts and developing a data base was assigned to V. Elser with the aim of finding some solution by the year 2001.

## Stability

The stability of quasicrystals is an important issue to explain to the origin of many subtle effects observed in electron, neutron and X-ray diffraction patterns. It was shown that processing and compositional variation played an important role in stabilizing the quasicrystalline phases. It is not surprising to encounter the conflicting results obtained from the same system by various groups. Therefore, it is important to mention the processing condition while discussing the stability aspects of the quasicrystals. Order–disorder transformation in icosahedral and decagonal phase was discussed. It was also seen that transformation from one superstructure to another superstructure appeared to be possible. For example, in Al–Pd–Mn, simple icosahedral, face centred icosahedral and diamond type superstructures were reported. Issues such as diffuse arcs, streaks and diffuse spots are yet to be explained based on structural details.

## Properties

Electronic properties of quasicrystals were extensively reported in the conference. The experimental evidence of electrical properties of QC demonstrated a pseudogap in the density of states near Fermi level. This phenomenon was explained by several groups on the basis of the complex motif present in the structure. It was also interesting to note that electronic properties of quasicrystals are more perturbed than those of approximants, perhaps because an aperiodic structure scatters the electrons more effectively than a periodic structure, which was subscribed to by many workers. The metal–insulator transition in Al–Pd–RE systems reported by the French group indicated the importance of understanding the transport phenomena of QC. It is also found that higher order RA structures, whose lattice parameters are more than 2.0 nm have similar properties compared to QC. A unique and new type of magnetic property coined as quasimagnetism was reported in Mg–Zn–RE based quasicrystals. Neutron diffraction results revealed the coexistence of narrow and wide magnetic peaks as well as the anomalous temperature dependence of these peaks, indicating the possibility of the presence of two different scales of magnetic correlation. Mechanical properties were also measured in many stable QC and discussed from the view point of their deformation behaviour. It was found that at high temperatures, material flow may be due to dislocation movement rather than grain boundary sliding or weakening. The dislocation movements, interaction and multiplication in QC was demonstrated by Knut Urban's group in Germany.

## Applications

It was shown by A. Inoue's group that bulk icosahedral alloys with high tensile strength, large elongation and high impact fracture toughness can be fabricated by the warm extrusion of atomized Al-base powders consisting mainly of nano-scale icosahedral phase embedded in an FCC phase. This area promises to open up new application such as a new type of Al-base composite alloys which may replace many commercial composite alloys. Ti-based QC alloy was shown by Kelton's group to possess the potential for hydrogen storage. The use of Al-base QCs was being used as efficient coating material with increased wear-resistance and non-sticking property and it was patented by J. M. Dubbois's group (France) earlier. Surface properties of these QCs were discussed with interest.

### Concluding remarks

The activities on quasicrystals are expected to continue and throw more light on unresolved issues. Apart from finding new systems of quasicrystals, a new type or class of quasicrystals along with more insight towards structure, stability, properties and new directions for potential technological applications seems to be happening. Therefore one can hope to get a better understanding and exciting results in this field by the 7th International Conference on Quasicrystals which is scheduled to be held in Stuttgart, Germany in 1999. It is pertinent to point out that the Indian scientists have made pioneering contributions in the area of quasicrystals[6]. As a recognition to Indian science, it has been recommended by the International Advisory Board to hold the 8th International Conference on Quasicrystals in India in the year 2001.

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**N. K. Mukhopadhyay and Arvind Sinha**, National Metallurgical Laboratory, Jamshedpur 831 007, India.

## RESEARCH NEWS

# Is cAMP necessary for *Dictyostelium* development?

*M. Azhar and Vidyanand Nanjundiah*

'Redundancy' has become a major puzzle in this age of genetic engineering: if doing away with the activity of a gene does not cause any difference to the phenotype, why is that gene there in the first place?[1] The situation is especially embarrassing when an organism appears capable of carrying on, to all appearances normally, without a supposedly essential gene product. A recent paper by Wang and Kuspa[2] makes this point forcefully by showing that haploid amoebae of *Dictyostelium* can complete a normal life cycle in the absence of *acaA*, the gene that encodes aggregation-specific adenylyl cyclase. To understand why this is so startling, one needs to go back to the past.

Ever since 1967, when it was first discovered[3], a series of elegant experiments have added evidence upon evidence in favour of the thesis that adenosine 3′–5′ cyclic monophosphate (cAMP) is *the* agent of communication between *Dictyostelium* amoebae. Indeed, cAMP-based signaling in *Dictyostelium discoideum* came to be regarded as a paradigm for intercellular communication in all of developmental biology. (Here we are talking of an unusual 'first messenger' role for cAMP over and above that of the ubiquitous 'second messenger'.) The life cycle of *D. discoideum* involves feeding, aggregation (following starvation) and differentiation into two cell types. Differentiation is initially apparent as a spatially segregated pattern of presumptive stalk (prestalk) and presumptive spore (prespore) cells within the multicellular aggregate (the slug), and latter as a mass of spores supported by a stalk of dead cells[4]. Each spore can germinate and give rise to an amoeba that can feed, grow and divide by mitosis and the cycle begins anew. Aggregation is caused by the secretion of a diffusible chemical attractant[5] and by the cell-to-cell transmission of an oscillatory signal[6,7]. cAMP synthesized and released periodically by starved amoebae, is capable of attracting competent cells from a distance and can be relayed from one cell to another[8]. The beautiful concentric and spiral waves of cell density that are seen during aggregation are overlaid by waves of cAMP concentration[9]. This last finding appeared to clinch the case for cAMP as a combined chemoattractant and transmitter that both mediated long-range intercellular signaling and was responsible for aggregation.

More was to follow. Genes that encoded products required for aggregation were shown to be specifically inducible by extracellular cAMP, and by pulsatile stimuli at that[10]. Harking back to classic experiments that demonstrated a positive spatial correlation within the slug between the ability of cells to release chemoattractant and their eventual fate[11], it appeared that cAMP, by evoking a differential chemotactic response in the two presumptive cell types, could also be responsible for the spatial patterning of cell types in the slug[12]. Finally, in combination with another small molecule, DIF, cAMP was shown to act as an inducer of cell type-specific gene expression[13] – though, surprisingly, the cell type that was induced corresponded to regions in the slug where cAMP levels appeared to be, relatively speaking, on the lower side.

Adenylyl cyclase is the enzyme that catalyses the formation of cAMP from ATP. *D. discoideum* has two adenylyl cyclase genes. One is expressed during development (*acaA*) and other during spore germination (*acaG*). *acaA*$^-$ mutants are unable to aggregate, but the deficiency can be overcome by subjecting cells to a regime of extracellular cAMP pulses followed by a steady concentration[14]. Extracellular cAMP cannot enter the cell[15]