20.X-1 SYMMETRY AND QUASICRYSTALS by Marjorie Senechal, Department of Mathematics, Smith College, Northampton, MA 01063, USA.

In 1901 in a report to the British Association for the Advancement of Science, the crystallographers William Barlow and Henry Miers observed that the history of the development of the theory of the structure of crystals

> ...is the history of an attempt to express geometrically the physical properties of crystals, and at each stage of the process an appeal to their known morphological properties has driven the geometrician to widen the scope of his inquiry and to enlarge his definition of homogeneity.

In the course of the succeeding 86 years the scope of the inquiry has steadily broadened, as the need for finer and finer geometrical classifications of crystal structure has been revealed by increasingly sophisticated instrumentation. In addition to the classical three-dimensional crystallographic groups, the standard working tools of the symmetry theorist now include n-dimensional groups, color groups, groupoids and graphs, and the list is growing. The discovery of quasicrystals poses new challenges, since it suggests that, no matter what the structure of these alloys turns out to be, any pattern which theoretically "diffracts" should have a place somewhere in the hierarchy of symmetry. Thus a central problem is to enlarge our definition of homogeneity to include all such patterns.

In this lecture I will survey some of the current attempts to characterize this class of patterns, and will try to assess their implications for a generalized concept of symmetry.

20.X-2 THE CRYSTALLOGRAPHIC RELEVANCE OF QUASICRYSTALS. By A. Janner and T. Janssen, Institute for Theoretical Physics, University of Nijmegen, Nijmegen, The Netherlands.

The concept of quasicrystal has been introduced in connection with the observation of diffraction patterns having icosahedral point group symmetry. For them various crystallographic higher-dimensional descriptions have been developed (Kramer and Neri, Katz and Duneau, Elser, Bak, Levine and Steinhardt, 1985). One may consider quasicrystals also as a special case of incommensurate crystal structures, for which a socalled superspace approach may be applied (de Wolff, Janner and Janssen). Then a comparison of the different formulations in higher-dimensional space is possible.

From the point of view of crystallography quasicrystals are more elementary objects than, for example, arbitrarily incommensurately modulated structures in that they may be described in first approximation as a filling of three-dimensional space with a small number of identical building units. (For periodic structures one such building block, the unit cell, is sufficient.) This similarity with three-dimensional generalisations of the Penrose tilings has intensively been exploited. It means that both in reciprocal and direct space the structure may be characterized by a number (larger than three) of integers.

Two other classes of incommensurate crystal phases, the modulated and the composite structures, were already known to occur in nature. The differences and the common points of the three classes will be discussed.

20.X-3 ELECTRON MICROSCOPY EVIDENCES OF QUASIPERIODICITY. BY M. Hirabayashi and K. Hiraga, The Research Institute for Iron, Steel and Other Metals, (Renamed Institute for Materials Research), Tohoku University, Sendai 980, Japan.

Continual efforts of high resolution transmission electron microscopy have currently been made to observe the quasicrystal structure of rapidly solidified aluminium-based alloys. Electron micrographs with the incident beam exactly parallel to the five-, three- and two-fold symmetry axes show non-periodic alignments of bright or dark dots exhibiting long-range quasiperiodic translational order and long-range orientational order. Characteristic features of these images are well interpreted with the projections of a model of the three-dimensional Penrose tiling which is composed of fat and skinny golden rhombohedra with the edge length of about 0.46nm.

When the icosahedral quasicrystal phase is heated up above 400°C, an intermediate structure appears before crystallization. In this structure, deviations from the quasiperiodicity are found frequently; the spacings of bright or dark dot alignment show localized periodicities as ···1T1T1T··· . Two-dimensional quasicrystal phases with decagonal symmetry of Al-Mn and Al-Fe alloys are considered to be an intermediate state between the three-dimensional quasicrystalline phase and a stable crystalline phase. The images with the incidence parallel to the ten-fold symmetry axis show non-periodic tiling patterns composed of two types of rhombs. These patterns are similar to but distinguished from the Penrose tiling constructed by matching and inflation rules, because periodic translational order appears in some local areas.

20.X-4 ABOUT QUASIPERIODIC DIFFRACTION SPECTRA. By John W. Cahn, Institute for Materials Science and Engineering, National Bureau of Standards, USA.

The ability to index diffraction spectra using a finite basis and to describe quasiperiodic structures as planar cuts of higher-dimensional periodic structures are consequences of the definition of quasiperiodicity that are useful in the study of quasicrystals. To illustrate these concepts single crystal-, as well as neutron and X-ray powder-, diffraction spectra of icosahedral phases will be indexed. The indexed intensities will then be Fourier-transformed to yield 3-dimensional quasiperiodic Patterson maps and 6-dimensional periodic Patterson maps. A comparison of these maps will be used to discuss the relative merits of quasiperiodic 3-dimensional versus periodic higher-dimensional descriptions.