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A spiral growth model for quasicrystals in two dimensions

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Abstract. Spiral space filling geometrical constructions using rhombuses in two dimensions are considered as plausible mechanisms for quasicrystal growth. These models will show staircase-like features which may be observed experimentally.

Keywords. Quasicrystals; tilings; five-fold symmetry.

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1. Introduction

Quasicrystals with five-fold rotational symmetry discovered by Shechtman *et al* (1984) are still posing difficulties regarding an understanding of the inherent atomic ordering. Various models for their structure have been proposed and are being subjected to rigorous tests by diffraction techniques. At present the facet formations and growth mechanisms of quasicrystals are centres of interest. This is because different types of microstructures and morphologies have been observed in different alloys and sometimes in the same alloy. The pentagonal dodecahedral morphology was observed in Ga–Mg–Zn icosahedral phase (Ohashi and Spaepen 1987). The triacontahedral morphology was seen in Al–Li–Cu alloy (Dubost *et al* 1986; Kortan *et al* 1989a). For a variety of morphologies observed in the icosahedral phase like a flower, a rosette and coral, a torus, dendrite etc. reference is made to Janot and Dubois (1988). The morphology of a decagonal prism was found in Al–Cu–Co decagonal quasicrystal (Kortan *et al* 1989b). None of the various models proposed for the quasicrystals has been able to fully explain both the facet formation and growth of quasicrystals. The icosahedral glass model (Stephens and Goldman 1986) proposes that since icosahedral ordering is favoured in these Al-alloys (Bergman *et al* 1957), rapid solidification can freeze the liquid structure leading to a glass like formation with orientational [illegible]. Such a freezing from liquid state will result in an abnormal decrease in density [illegible] when compared to its crystalline form, owing to the void space between the icosahedral clusters. In this model a growth mechanism for quasicrystal is not predicted and the quasicrystal is expected to be entropically stabilized. The Penrose tiling model (Levine and Steinhardt 1984; Kramer and Neri 1984; Jaric 1986; Socolar and Steinhardt 1986; Sasisekharan 1986; Elser 1987; Steinhardt and Ostlund 1987) proposes that there are two types of rhombohedra which arrange themselves quasiperiodically in three dimensions through a matching rule similar to the Penrose matching rule (Penrose 1974; Mackay 1982) for two dimensional tilings. This tiling model is supported by the observed triacontahedral morphology (Dubost *et al* 1986; Kortan *et al* 1989a).