# Steady-state propagation of dislocations in planar quasicrystals

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**ABSTRACT.** Quasicrystals (QC), namely a particular class of metal alloys displaying intrinsic structure defects, attracted wide interests in the past two decades for their promising applications in many engineering fields. Their atomic structure displays symmetries forbidden by the standard classification of crystallographic groups, which are not compatible with a periodic arrangement of atoms in a cell. They indeed possess a quasi periodic structure, resulting from a continuous atomic rearrangement of the crystalline phase. In this process, the non commensurate phase, whose symmetry differs from the prevailing one, is continuously destroyed and rearranged in agreement with the prevailing atomic structure. From the point of view of mechanical modeling, the local rearrangement of atoms in a cell can be described by a phason activity, whereas the macroscopic deformation of the lattice is modeled by the phonon field as in classical elasticity. Similar structures are frequently found in aluminium alloys (Al-Cu-Fe, etc).

Dislocations play a key role as regards the mechanical properties of crystalline materials, since they influence the ductility and strength as well as the work hardening behavior. Similarly to crystals, dislocations in QCs are responsible for their mechanical properties. However, dislocations in QCs are special in that they are accompanied by both phonon and phason strain fields. Based on the existence of this phason strain, the characteristic features of dislocations in QC are somewhat different from those in crystals. In QC materials, the high-energy phason faults make the dislocations immobile in the low temperature range where atomic diffusion is not allowed, leading to brittle fracture occurring by an intergranular process. Consequently, QCs display a brittle behavior at room temperature and intermediate temperatures, like any intermetallic compound. However, at elevated temperatures QC materials become ductile. Dislocation motion is proposed to be one important mechanism for the high-temperature plastic deformation of Al–Cu–Fe QCs.

As the dislocation propagates the phonon strain field relaxes instantaneously whereas the relaxation time of the phason strain is slower, since it is governed by the atomic diffusion process. At low temperatures, the phason strain cannot move with the dislocation thus producing a phason fault along the glide plane behind the dislocation. At intermediate temperatures, dislocations migrate trailing a partially relaxed phason strain field. At high temperatures, the atomic mobility is faster and the dislocation can migrate together with phonon and phason strains.

In the present work, we investigate steady-state propagation of a dislocation in an elastic QC with fivefold symmetry occurring at speed lower than the shear wave velocity. A closed form solution for phonon and phason stress and displacement fields is provided for a gliding and/or climbing dislocation, within the infinitesimal deformation setting. Viscous-like dissipation within material elements is neglected since the analysis is developed at a time smaller than the characteristic activation time. One of the aim of the present paper is to explore the effects of phason-phonon coupling on the propagation of dislocations. The coupling coefficient between the gross deformation and the atomic rearrangements is expected to play a fundamental role on the activation of the energy dissipation mechanisms in QC an thus its influence on the formation of the

phason-wall during the propagation of dislocations in QC will be systematically investigated. The method adopted for determining the explicit expressions of the fields induced in a QC material by the propagation of a dislocation is an evolution of a previous approach employed in (Radi and Mariano, 2010, 2011) for the analysis of crack propagation in QC and is based on the Stroh formalism (Stroh, 1958, 1962). An explicit expression for the energy per unit length of a moving dislocation in icosahedral quasicristals is derived. It is shown that the expression is closely related to the energy release rate for a steadily moving crack (Radi and Mariano, 2010).

## REFERENCES


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