Poster Presentation

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A cubic quasicrystal in a rapidly-solidified Mg-Al alloy

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It is commonly accepted that the definition of quasicrystal should include a rotational symmetry forbidden in periodic crystals. On the other hand, the quasicrystal with a conventional point group is theoretically possible [1,2]. In a rapidly-solidified Mg-Al alloy, intriguing electron diffraction patterns (EDPs) were reported, which show a cubic symmetry with aperiodic arrays of Bragg reflections [2]. In the present work, we investigate the detailed structure of the rapidly-solidified Mg-Al phase based on direct structure observations using STEM. In a rapidly-solidified Mg-61 at.% Al alloy, 2-fold, 3-fold, and 4-fold EDPs are obtained (Fig. a), which shows that the structure has the cubic point group. However, the relevant diffraction spots are arranged aperiodically. Especially in the 2-fold EDP, a high density of the spots is observed, and the corresponding HADDF-STEM image shows several remarkable features (Fig. b). Two length scales, L and S, can be definitely observed, and they are arranged quasiperiodically along the 3-fold axis. Their arrangement can be well described by the hyperspace crystallography; a physical space tilted by the angle θ, where $\tan\theta \sim 1.4$, successfully generates the observed quasiperiodic pattern. Simulated EDPs from a simple model without detailed atomic decoration reproduces fairly well the experimental patterns. Further analysis of the images reveals that the present quasiperiodic structure has similar local structure to the stable β-Mg_2Al_3 phase; two lengths correspond to L and S may be reasonably defined. The quasicrystal with a cubic symmetry is unambiguously determined for the first time, based on a direct structural observation. The present results strongly suggest that the noncrystallographic rotational symmetry is not an essential factor to form the quasiperiodic structure, raising a very fundamental, universal question on the physical origin of a long-range order of condensed matters.

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