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Vacancy assisted flow of solid helium

The idea that solid helium might become a supersolid goes back to Andreev and Lifshiz [1]. The 2004 observation of supersolidity in torsional oscillator experiments by E. Kim and M. Chan [2] started an extensive worldwide series of related investigations. Since the report by D. Y. Kim and M. Chan in 2012

Key words: helium, solid, temperature, low temperature

Дж. Бенедик, А. Калинин, П. Ниетто, Дж П. Тоенис

Содействие вакансии потоку твердого гелия

Идея, что твердый гелий может стать сверхтвердым веществом, предсказана Андреевым и Лившицем [1]. В 2004 г. Э. Ким, М. Чен начали широкую международную серию соответствующих исследований сверхтвердого вещества по методике экспериментально крутильных осцилляторов [2].

Ключевые слова: гелий, твердое тело, температурный режим, низкие температуры.

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Бос орынның қатты гелийдің ағынына көмектесуі

Қатты гелий аса қатты зат болуы мүмкін деген идеяны Андреев және Ливщиц болжап айтқан болатын [1]. 2004 ж. Э. Ким, М. Чен халықаралық осы идеяға сәйкес зерттеулердің топтамасын жүргізген, аса қатты заттың айналатын тәжірибелік осцилляторлардың әдістемесі бойынша зерттеулер жүргізілген [2].

Түйін сөздер: гелий, қатты дене, температуралық режим, төменгі температуралар.

The idea that solid helium might become a supersolid goes back to Andreev and Lifshiz [1]. The 2004 observation of supersolidity in torsional oscillator experiments by E. Kim and M. Chan [2] started an extensive worldwide series of related investigations. Since the report by D. Y. Kim and M. Chan in 2012 [3] that their effect was spurious, interest in the phenomenon has largely subsided. In 2001 GalliandReatto predicted that another type of supersolidity might occur at temperatures close to the lambda line provided that the concentration of vacancies is sufficiently large.[4] This has inspired our experiments which take advantage of the geyser effect [5] in which vacancy diffusion from the vacuum side of a flow system leads to a sudden collapse of the solid. The resulting flow through a 0.1 mm dia 14 mm long capillary is monitored by pressure sensors up- and downstream of the capillary at temperatures between 1.64 to 2.66 K and pressures up to 102 bar. After the initial sharp geyser pressure pulse, three different capillary flow regimes are observed as the upstream pressure decrease: (1) an oscillatory (minigeyser) regime. (2) a constant flow regime with a linearly decreasing pressure gradient, and (3) a non-resistant regime. The comparative analysis of the three regimes indicates that the flow of solid 4He is driven by a coherent counterflow of excess vacancies, which are injected at the solid/

liquid interface near the micrometric orifice exposed to vacuum. In the constant flow regime the velocity of about 20 cm/s, which is independent of the pressure gradient, is interpreted as evidence for a new phase of solid helium induced by non-equilibrium vacancies, in agreement with recent theories.

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