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Application of impedance spectroscopy for studying of charged nanoclusters in impurity-helium condensates

A gas jet consisting of a mixture of helium and impurity (~ 1% of H₂, N₂, Ne, Kr, Xe, etc.) gases was directed onto the surface of superfluid helium (HeII) contained in the glass beaker. During condensation of the impurity particles in the bulk superfluid helium the so-called impurity-helium condensate is formed [1].

Recently in 2013, charges were detected for the first time during destruction of the nitrogen-helium samples [2]. For further investigations it was proposed to use methods of the impedance spectroscopy. We used a sensor of planar geometry with two conductive meanders (the sensor capacity was of 7.9 pF).

Key words: impedance spectroscopy, superfluid helium impurity-helium condensates.

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Применение импедансной спектроскопии для изучения заряженных нанокластеров примесь-гелиевых конденсатов

Газовая струя, состоящая из смеси гелия и примеси (~ 1% of H₂, N₂, Ne, Kr, Xe, и т.д.), направляется на поверхность сверхтекучего гелия (He-II), находящегося в стеклянной мензурке. В процессе конденсации частиц примеси в объеме сверхтекучего гелия формируется так называемый примесь-гелиевый конденсат. Результаты работы подтверждают гипотезу о существовании заряда на стадии разрушения примесь-гелиевых образцов. Природа зарядов и механизмы их появления все еще остаются открытыми и требуют дальнейшего изучения.

Ключевые слова: импедансная спектроскопия, сверхтекучий гелий, примесь-гелиевый конденсат.

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Импедансты спектроскопияны гелий-қоспалы конденсаттардың зарядталған нанокластерлерін зерттеу үшін қолдану

Гелийден және қоспалардан (~ 1% of H₂, N₂, Ne, Kr, Xe, және т.б.) тұратын газдық ағыс шыны мензуркада орналасқан асқын аққыш гелийдің (He-II) бетіне бағытталады. Қоспаның бөлшектерінің конденсация процесінде асқын аққыш гелийдің көлемінде гелий-қоспалы конденсат түзіледі. Жұмыстың нәтижелері гелий-қоспалы үлгілердің бұзылу сатысында зарядтың болуы туралы болжамды растайды. Зарядтардың табиғаты және олардың пайда болу механизмдері әлі де толық ашылмаған болып табылады және әрі қарай зерттеуді қажет етеді.

Түйін сөздер: импедансты спектроскопия, асқын аққыш гелий, қоспа-гелийлі конденсат.

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was proposed to use methods of the impedance spectroscopy. We used a sensor of planar geometry with two conductive meanders (the sensor capacity was of 7.9 pF). In the experiments the temporal dependencies of the impedance were carried out at frequencies of 2700 and 3000 Hz. The voltage amplitude was of 5 V.

Synchronously with lowering of helium level in the glass beaker, the sample shrinks and then destroys through explosions accompanied with current pulses and bright flashes. Simultaneously with explosions, temperature and pressure peaks, as well as resistance and capacitance jumps were observed.

These results support the hypothesis of charge existence at the stage the destruction of the impurity–helium samples. The nature of the charges and mechanisms of their appearance are still open questions and demand further study.

The measuring technique with use of the planar sensor has shown good performances and allowed to investigate the behavior of the impurity–helium samples in HeII as well as during their destruction processes.

The described construction of the sensor is very simple, easily reproducible and may be applied in investigations of low-temperature films, coats, and matrices.

References

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