PUBLICATIONS ET BREVET

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MICROSCOPIC DYNAMICS OF SUPERFLUID ^{4}HE: A COMPREHENSIVE STUDY BY INELASTIC NEUTRON SCATTERING, **PHYS. REV. B 97,** 184520 (MAY 30, 2018)

K. Beauvois, J. Dawidowski, B. Fåk, H. Godfrin, E. Krotscheck, J. Ollivier and A. Sultan

Abstract: The dynamic structure factor of superfluid 4He has been investigated at very low temperatures by inelastic neutron scattering. The measurements combine different incoming energies resulting in an unprecedentedly large dynamic range with excellent energy resolution, covering wave vectors Q up to 5 ˚ A −1 and energies ω up to 15 meV. A detailed description of the dynamics of superfluid 4He is obtained from saturated vapor pressure up to solidification. The single-excitation spectrum is substantially modified at high pressures, as the maxon energy exceeds the roton-roton decay threshold. A highly structured multi-excitation spectrum is observed at low energies, where clear thresholds and branches have been identified. Strong phonon emission branches are observed when the phonon or roton group velocities exceed the sound velocity. The spectrum is found to display strong multi-excitations whenever the single-excitations face disintegration following Pitaevskii's type a or b criteria. At intermediate energies, an interesting pattern in the dynamic structure factor is observed in the vicinity of the recoil energy. All these features, which evolve significantly with pressure, are in very good agreement with the Dynamic Many-body calculations, even at the highest densities, where the correlations are strongest.

BREVET : DISPOSITIF CRYOGENIQUE A ECHANGEUR COMPACT (2017)

En cours de publication

ALTAN JT: A HIGH PERFORMANCE FAST COOL DOWN INFRARED DETECTOR FOR MISSILE APPLICATIONS, CONFERENCE PROCEEDINGS, **IAMD (2017)**

Ahmad Sultan, Yann Reibel, Emmanuel Lacroix-Desmazes, Romain Galand, Antoine Kessler, Noura Matallah, Maxime Taupin

Abstract: SOFRADIR is a pioneer industry and a leading merchant supplier of a broad array of high technology infrared sensors for military, space, industrial and commercial applications. The company, with its broad expertise backed by 30 years of experience, continues to head most of important developments and production of infrared detector projects for major programs in Europe as well as in other parts of the world. Among a broad choice of high performance infrared detectors, we focus on 4 product families developed to address a wide range of missile applications from anti-tank missiles to cruise missiles. Their

main key aspects will be discussed in this paper. This document is, in great part, devoted to the compact, lightweight and high performance Altan JT IDDCA which recently joined the family of JT-based based detectors. Its high resolution, high frame-rate and highly competitive cryogenic and electro-optical performance make Altan JT product the best solution for air-to-air missiles and surface-to-air missiles.

HIGH PERFORMANCE INFRARED FAST COOLED DETECTORS FOR MISSILE APPLICATIONS, 2016, **SPIE 9819, INFRARED TECHNOLOGY AND APPLICATIONS XLII,** 98190I (MAY 20, 2016)

Yann Reibel, Laurent Espuno, Rachid Taalat, Ahmad Sultan, Pierre Cassaigne, Noura Matallah

Abstract: SOFRADIR was selected in the late 90's for the production of 320×256 MW detectors for major European missile programs. This experience has established our company as a key player in the field of missile programs. SOFRADIR has since developed a vast portfolio of lightweight, compact and high performance JT-based solutions for missiles. ALTAN is a 384x288 Mid Wave infrared detector with 15µm pixel pitch, and is offered in a miniature ultra-fast Joule-Thomson cooled Dewar. Since Sofradir offers both Indium Antimonide (InSb) and Mercury Cadmium Telluride technologies (MCT), we are able to deliver the detectors best suited to customers' needs. In this paper we are discussing different figures of merit for very compact and innovative JT-cooled detectors and are highlighting the challenges for infrared detection technologies.

ELECTRICAL CONDUCTANCE OF BOLTED COPPER JOINTS FOR CRYOGENIC APPLICATIONS, **JOURNAL OF LOW TEMPERATURE PHYSICS 175**:877–887 (2014)

Florent Blondelle, Ahmad Sultan, Eddy Collin, Henri Godfrin

Abstract: We present the results of electric contact resistance measurements at low temperatures on copper-to-copper bolted joints. Our accurate and systematic data display a rather small dispersion, and may be a useful tool for cryogenic applications like pulse-tubes, dilution refrigerators and nuclear refrigerators.

AN ABOVEGROUND PULSE-TUBE-BASED BOLOMETRIC TEST FACILITY FOR THE VALIDATION OF THE LUMINEU ZNMOO4 CRYSTALS, **JOURNAL OF LOW TEMPERATURE PHYSICS 176**:571–577 (2014)

M. Mancuso, D. M. Chernyak, F. A. Danevich, L. Dumoulin, A. Giachero, A. Giuliani, H. Godfrin, C. Gotti, I.M. Ivanov, M. Maino, E.P. Makarov, E. Olivieri, G. Pessina, V.N. Shlegel, A. Sultan, M. Tenconi, Ya.V. Vasiliev

Abstract: The LUMINEU project aims at developing a pilot double β decay experiment using scintillating bolometers based on ZnMoO4 crystals enriched in ^{100}Mo. In the next months regular deliveries of large-mass ZnMoO4 crystals are expected from the Nikolaev Institute of Inorganic Chemistry (Novosibirsk, Russia). It is therefore crucial for the LUMINEU program to test systematically and in real time these samples in terms of bolometric properties, light yield and internal radioactive contamination. In this paper we describe an aboveground cryogenic facility based on a dilution refrigerator coupled to a pulse-tube

cooler capable performing these measurements. A 23.8 g ZnMoO4 crystal was fully characterised in this setup. We show also that macro-bolometers can be operated with high signal-to-noise ratio in liquid-free dilution refrigerators.

OBSERVATION OF A ROTON COLLECTIVE MODE IN A TWO-DIMENSIONAL FERMI LIQUID, **NATURE 483**, 576–579 (2012)

Henri Godfrin, Matthias Meschke, Hans-Jochen Lauter, Ahmad Sultan, Helga M. Böhm, Eckhard Krotscheck and Martin Panholzer

Abstract: Understanding the dynamics of correlated many-body quantum systems is a challenge for modern physics. Owing to the simplicity of their Hamiltonians, ^{4}He(bosons) and ^{3}He(fermions) have served as model systems for strongly interacting quantum fluids, with substantial efforts devoted to their understanding. An important milestone was the direct observation of the collective phonon–roton mode in liquid ^{4}He by neutron scattering, verifying Landau's prediction and his fruitful concept of elementary excitations. In a Fermi system, collective density fluctuations (known as 'zero-sound' in ^{3}He, and 'plasmons' in charged systems) and incoherent particle–hole excitations are observed. At small wave-vectors and energies, both types of excitation are described by Landau's theory of Fermi liquids. At higher wave-vectors, the collective mode enters the particle–hole band, where it is strongly damped. The dynamics of Fermi liquids at high wave-vectors was thus believed to be essentially incoherent. Here we report inelastic neutron scattering measurements of a monolayer of liquid ^{3}He, observing a roton-like excitation. We find that the collective density mode reappears as a well-defined excitation at momentum transfers larger than twice the Fermi momentum. We thus observe unexpected collective behavior of a Fermi many-body system in the regime beyond the scope of Landau's theory. A satisfactory interpretation of the measured spectra is obtained using a dynamic many-body theory.

TWO-DIMENSIONAL FERMI LIQUIDS SUSTAIN SURPRISING ROTON-LIKE PLASMONS BEYOND THE PARTICLEHOLE BAND., **J. PHYS. CONF. SER. 340**, 012078 (2012)

A. Sultan, H. Godfrin, M. Meschke, H.-J. Lauter, H. Schober, H. Böhm, R. Holler, E. Krotscheck and M. Panholzer

Abstract: Using inelastic neutron scattering we have observed for the first time the elementary excitations of an isotropic two-dimensional Fermi liquid, ^{3}He adsorbed on graphite. This interacting many-body system sustains, at low wave-vectors, a zero-sound collective mode located near the edge of the particle-hole band. The mode crosses the particle-hole band, undergoing Landau damping, and finally reappears at high wave-vectors, where a roton-like mode is observed. This feature is characteristic of correlations, rather than statistics. This collective mode is found to be well defined in two-dimensional ^{3}He, and might also be present in other Fermi correlated systems. The observed coherence effects suggest a novel superconductivity pairing mechanism based on high wave-vector plasmons, specific to two-dimensional electronic correlated systems, like high Tc superconductors, heavy fermions, metallic films and graphene.

STATIC STRUCTURE FACTOR OF TWO-DIMENSIONAL LIQUID HE-3 ADSORBED ON GRAPHITE, **JOURNAL OF LOW TEMPERATURE PHYSICS 169**, 367-376 (2012)

A. Sultan, M. Meschke, H.-J. Lauter, H. Godfrin

Abstract: Liquid ^{3}He is a model system for strongly correlated Fermi liquids. For this reason, many X-ray and neutron scattering experiments have been performed to understand the structure and dynamics of this quantum fluid. We have recently shown that two-dimensional liquid ^{3}He sustains long-lived zero-sound excitations at large wave-vectors (Nature 483, 576, 2012). Here we show that its static structure factor can be obtained with reasonable accuracy by integrating the experimental S(Q,ω) over a suitable energy range. A good agreement is found between the static structure factor deduced from the experiment and theoretical models: Quantum Monte Carlo simulations and Dynamical Many Body Theory (DMBT). At high wave-vectors, the experimental values are underestimated because of the limited accessible phase space; nevertheless, even at atomic wave-vectors a semi-quantitative agreement is observed with the theoretical predictions.

DYNAMICS IN QUANTUM FLUIDS: STUDY OF COLLECTIVE EXCITATIONS IN A TWO-DIMENSIONNAL FERMI LIQUID, **THESIS**, **UNIVERSITÉ JOSEPH FOURIER** (2012)

A. Sultan

Abstract: ^{4}He and ^{3}He are model systems for understanding quantum properties of strongly interacting matter. For this reason, many studies have been devoted for the understanding of their dynamics. At low temperatures at which quantum effects play an essential role, the elementary excitations in ^{4}He are described by a phonon-roton collective mode. For ^{3}He, the physical description is more complicated, the spectrum has two components: collective excitations (zero-sound) and incoherent particle-hole excitations. Both are described by Landau's theory of Fermi liquids which is valid at low wave vectors. So far, it was thus believed that the dynamics at high wave vectors is essentially incoherent. This thesis is mainly concerned by exploring the collective excitations of a two dimensional ^{3}He film adsorbed on graphite, using inelastic neutron scattering. Such an experiment has three main requirements: a dilution refrigerator in order to work at low temperatures, a time of flight spectrometer for measuring the dynamical structure factor of ^{3}He and a solid substrate (exfoliated graphite ZYX) to obtain a two dimensional film by physical adsorption. Our investigations of the dynamics in two-dimensional ^{3}He adsorbed on graphite pre-plated with ^{4}He films have revealed important features: At low wave-vectors, the zero sound mode is considerably depressed compared to bulk ^{3}He. At higher wave vectors, the collective excitations branch enters the particle-hole continuum, and reappears at the lower energy branch of the continuum. This new branch, observed for the first time, is described by the dynamic many-body theory developed by our collaborators from Johannes Kepler University, Linz, Austria. During this work several low temperature techniques have been developed, in particular a robust, cryogen-free dilution refrigerator adapted to the demanding conditions of a neutron scattering experiments. Due to its efficient design, the cooling time has been considerably reduced compared to that of refrigerators of the same type developed in the past.