AMENDMENT REQUEST

Project acronym:	**Microkelvin**
Project title:	**European Microkelvin Collaboration**
Grant agreement no.:	**228464**

Justifications

We request on behalf of the consortium to accept a change of the person of the coordinator and two modifications in the list of tasks in Annex I. These three changes are of force majeure type, they are separate requests, and can be approved independently.

Request 1

Prof. Mikko Paalanen will no longer assume the role of *coordinator* of the Microkelvin Project and will be replaced by Prof. Matti Krusius from November 1, 2011.

Prof. Paalanen has been on leave of absence since September 27, 2010 because of severe illness. He expects to go on retirement September 1, 2011.

Since we represent the same beneficiary, the Aalto-korkeakoulusäätiö (Otakaari 1, Espoo 02015, Finland) the address and the bank account details remain unchanged.

This motion is requested on behalf of the Microkelvin project as discussed and accepted in the Microkelvin General Assembly Meeting March 16, 2011. The minutes of the meeting are included as an attachment.

Request 2

Modification of Annex I - Description of Work

We ask for modifications in Tasks 3 and 5 of Joint Research Activity No. 3. The work plan in Annex I was drafted more than three years ago. Unforeseen difficulties have caused delays in these two Tasks. We propose to compensate for the unfinished projects by extending work in other tasks beyond the goals described in Annex I. These modifications were discussed and accepted in the Microkelvin General Assembly Meeting March 16, 2011.

JRA3 Task 3: One of the goals of this task is to construct an experimental quantum analogue model of Black-Hole horizons and search for possible Hawking radiation. This work is delayed owing to the need for better understanding of the dynamic responses of quantized vortices in the zero temperature limit, $T \rightarrow 0$. According to present view this is the temperature regime where the analogue model would be most sensitive. The delay causes modifications in the Milestones and Deliverables of JRA3 as detailed in the attached revision to Annex I.

Justification: No quantum version of a hydrodynamic Black-Hole model has so far been experimentally realized. Superfluid ^{3}He provides a good opportunity, but better understanding of its properties and its measuring techniques is called for, to improve the significance of the results. The zero temperature limit, $T \to 0$, is a regime of limited understanding which currently is in the forefront of the work performed in Task 1 of JRA3 [see *I.A. Bradley et al., in Nature Physics* ***7****, 473 (2011) and J.J. Hosio et al., in Physical Review Letters* ***107****, 135302 (2011)*]. In addition improved measuring techniques are evolving from the work in Task 4 of JRA3 for this temperature regime. We expect these two developments to pave the road towards a more informative Black-Hole experiment. For these reasons we are investing more efforts in both Tasks 1 and 4, while delaying part of the work on the Black-Hole model in Task 3.

Modifications: The shift in emphasis causes a delay in Milestone M6. We propose a less ambitious wording and time limit in Milestone M6. As compensation we add a new Milestone in Task 4 which calls for measurements on the speed up in nuclear spin relaxation from surfaces and from vortex cores in trapped magnon condensates of the Q-ball type. These changes imply that Deliverable D4, a publication on the Black-Hole model and its physics, will be relaxed to a report describing a new plan for a forthcoming model experiment, with a deadline moved from 36 months to 48 months, while Deliverable D5 on Q-ball measurements has been stepped up to include the Q-ball relaxation results.

JRA3 Task 4: This investigation deals with the coherently precessing low-temperature NMR mode of ^{3}He-B, the spin Q-ball state which in newer language is called a Bose-Einstein condensate of magnons in a harmonic trap formed by the order parameter texture. Its study has been stepped up to measure its slow spin relaxation rate and the enhancement of this rate in the presence of surfaces and vortex cores. These efforts are part of currently popular work on topological insulators, of which superfluid ^{3}He-B is the best example. The measurements might provide insight in the zero energy “Majorana fermion states” of this topological insulator at the lowest temperatures. The measuring techniques could ultimately play a major role in improving the measuring sensitivity in the $T \to 0$ regime and in particular in the case of the Black-Hole analogue experiment.

Modifications: A new milestone M12 has been added (at 42 months) which reports on the relaxation measurements in rotating superfluid ^{3}He in the presence of vortices and surfaces.

Request 3

Modification of Annex I - Description of Work

JRA3 Task 5: The ULTIMA particle detector, which uses superfluid ^{3}He-B at μK temperatures as the target material, is potentially the most energy-sensitive device for dark-matter detection. The plan to set up a small-scale pilot version of the dark-matter observatory in an underground laboratory has run in difficulties and is delayed. We propose to substitute this plan with above-ground development work of the detector instrumentation and with studies of the rapid non-equilibrium processes in the target material in particle collisions.

Justification: The micromechanically manufactured detection instrumentation has now been developed. According to the original plan in Annex I the next phase would be the installation of a small-size pilot experiment to an underground laboratory and to investigate its operational characteristics. However, the goal to start this phase of the dark-matter observatory ULTIMA in the Canfranc Laboratory in the Pyrenees Mountains has met with difficulties: 1) The project proposal received the first step of French funding for the required measuring equipment, but not the second step for man power to set up and operate the observatory in Canfranc. Moreover, the availability and the price of the target material, ^{3}He gas, have become a major obstacle: the price has increased 20-fold since drafting the plans for ULTIMA. 2) The second difficulty is that the Canfrac underground laboratory suffered a serious collapse of its roofing, which during the first two grant years prevented access to the laboratory. Since then French underground research has been directed mainly to Modane where the ULTIMA plan should now be accepted and relocated. For these "force majeure" reasons ULTIMA is delayed and will play no major role during the present Microkelvin grant period.

Modifications: The small-size multi-cell particle detector will be installed in the laboratory above ground. Test runs will be performed with the detector to study the effect of pressure and magnetic field on the sensitivity and the correlations in the output of the different energy-sensitive sensors. A detailed analysis of the recovery time of the detector will be performed, with the objective to investigate the discrimination of different events on the basis of variations in the delay of their heat deposition. The distribution of the detectors' recovery times will be measured and compared to simulations.

In addition we propose to investigate interactions of the incoming particle with the target material - the superfluid ^{3}He-B absorber – which involve a broad energy range. The distribution of the collision energy ranges from as high as 764 keV (capture reaction of a slow thermal neutron) to μeV (thermal excitations). At very low energies the thermal excitations are well described in terms of Landau's Fermi liquid theory. At very high energies, in turn, a good description is available in terms of the impulse approximation theory. We shall examine with inelastic neutron scattering the creation of excitations in the meV range where coherent and incoherent excitations coexist, to understand the system dynamics and the relaxation processes after a detected event.

In parallel, studies of silicon sensors of different shapes and with different drive configurations will determine their limitations due to non-linearity and material properties. These above-ground measurements will establish the limiting sensitivity achievable with micromechanically fabricated oscillators.

The above changes in the work programme cause modifications in two milestones and two deliverables: Former Milestone M12 is relaxed to above ground tests with a deadline at 42 months, while former Milestone M13 (with the multi-cell particle detector operating underground) is replaced by measurements of the ^{3}He excitation spectrum at intermediate energies. Similarly Deliverable D6, which reports on the underground-operated multi-cell particle detector, is replaced by a report on the state-of-the art superfluid ^{3}He particle detectors. A new deliverable D7 is added which reports on the ^{3}He excitation spectrum at 48 months.
