

The 2008 Fritz London Memorial Prize Winners

**Yuriy Bunkov, Vladimir V. Dimitriev, Igor Fomin
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Yuriy M. Bunkov



Vladimir V. Dmitriev



Igor Fomin

Yuriy M. Bunkov, Vladimir V. Dmitriev, and Igor A. Fomin have been named winners of the 2008 Fritz London Memorial Prize.

The citation reads:

“For the discovery and understanding of unique phenomena in superfluid $^3\text{He-B}$: macroscopic phase-coherent spin precession and the flow of spin supercurrent.” The latter is a magnetic counterpart of mass-current superfluidity in helium liquids and Bose-Einstein condensates, and charge-current superfluidity in superconductors.”

This is an award for a unique phenomenon involving spontaneous phase coherent macroscopic precession of the magnetization of supercurrents in superfluid $^3\text{He-B}$ and the flow of spin supercurrent [1, 2]. The latter is a magnetic counterpart of mass-current superfluidity in helium liquids and Bose-Einstein condensates (BECs) and of charge-current superfluidity in superconductors. It is also an example of the BEC of spin-wave excitations or magnons.

Since their discovery they have established many other consequences of this BEC state, such as the spin supercurrent, spin-current Josephson effect, spin-current vortices, and nontopological solitons (called Q-balls in high energy physics). They also developed new measuring techniques based on coherent spin precession, which made it possible to

observe other novel effects in ^3He superfluids, such as a vortex terminating on a soliton sheet, the observation of the Goldstone mode of the vortex with non-axisymmetric core in $^3\text{He-B}$, the identification of the order parameter of ^3He in aerogel via a measurement of the $^3\text{He-B}$ Leggett angle, and the observation of coherent precession in $^3\text{He-A}$, to name a few.

Since its discovery by Osheroff, Richardson and Lee in 1972, superfluid ^3He has been a fertile field of research. The purity of the material and the multi-dimensional order parameter manifold have made this quantum state of triplet Cooper pairing an attractive laboratory for the study of the superfluidity in a magnetically ordered quantum liquid crystal environment. The system also has many properties in common with relativistic quantum fields and has turned into a playground for testing several new ideas relevant to particle physics and cosmology. The unusual spin dynamics and NMR properties of superfluid $^3\text{He-B}$ are at the source of the discovery. Inhomogeneity in the spin precession frequency creates spin supercurrents, which redistribute the magnetization in such a way that the precession becomes uniform. Traces of long-lived magnetic precessing states had been seen earlier by Corruccini and Osheroff and also by a group in Helsinki. However the first long-lived induction signal with a large amplitude corresponding to the coherent precession of the whole magnetization was discovered and understood by Borovik-Romanov, Bunkov, Dmitriev and Mukharskii in 1984 [1]. The crucial point was the observed time dependence of the precession frequency, which triggered the Fomin theory of the domain with homogeneous precession, whose boundary moves with time [2]. This domain was called the Homogeneously Precessing Domain (HPD). The main property of such precessing states is a coherence of the phase in the Larmor precession throughout the whole domain, which persists even in the presence of inhomogeneous external magnetic fields. This is the first example in nature of a magnetic analog of the off-diagonal long-range order observed in phase-coherent Bose condensates, superfluids, and superconductors. Thus this phenomenon is the first true realization of spin superfluidity.

The three winners are all widely known low temperature physicists:

Yuriy M. Bunkov — worked at the Kapitza Institute in Moscow until 1995, in the laboratory of academician A.V.S. Borovik-Romanov, where he constructed the first nuclear demagnetization refrigerator in Soviet Union and performed much of the early research. Since 1995 he has been “Directeur des Recherches” in the Institute of Ultra Low Temperature Research in Grenoble, where he has continued to make important contributions to the subject matter described here. He also participates in measurements in Helsinki, Lancaster, Tokyo, and Kyoto where he found new types of coherent states in bulk ^3He and in ^3He in aerogel, and where he has applied his measuring techniques based on coherent precession to quantized vortices in rotating flow. He is well known for his work on the Kibble-Zurek mechanism in superfluid $^3\text{He-B}$, the equivalent of cosmic string formation in cosmological phase transitions.

Vladimir V. Dmitriev — started his career at the Kapitza Institute in Moscow in the experimental group of Dr. Yu. Bunkov. He participated in the construction of the nuclear cooling cryostat and was part of the experimental work which led to the original

discovery of the HPD state. He is now the head of the Ultra Low Temperature group in the Kapitza Institute and a corresponding member of the Russian Academy of Sciences. He significantly expanded the field of research on magnetically excited coherent spin states with his well-known later work on the first observations of precessing magnetic domains in Fermi liquids and in ^3He in aerogel.

Igor A. Fomin — worked at the Landau Institute for Theoretical Physics in Moscow and since 1993 at the Kapitza Institute in Moscow. He is a corresponding member of the Russian Academy of Sciences. He constructed the theory of magnetically excited coherent quantum states and of spin supercurrent transport and applied these to the explanation of the actual measurements. He also suggested a theory on the order parameter states of ^3He in aerogel.

[1] A.S. Borovik-Romanov, Yu.M. Bunkov, V.V. Dmitriev, and Yu.M. Mukharskiy, "*Long Lived Induction Decay Signal Investigations in ^3He* ", JETP Lett. **40**, 1033 (1984).

[2] I.A. Fomin, "*Long-lived induction signal and spatially nonuniform spin precession in $^3\text{He-B}$* ", JETP Lett. **40**, 1037 (1984).