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# Ultrahigh-resolution neutron spectroscopy of low-energy spin dynamics in UGe2

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Novel electronic phases such as nematic electronic textures or unconventional superconductivity (SC) are frequently observed near zero-temperature magnetic instabilities that arise as a function of a non-thermal control parameter such as pressure. Although it is widely believed that the abundant magnetic fluctuations associated with these quantum phase transitions (QPT) are at the origin of the emergence of novel electronic states, their exact nature remains an outstanding question. Notably, according to theory both the relaxation time and correlation length of the fluctuations are expected to diverge when the quantum critical point is approached. However, to date these divergences have not yet been observed due to the demanding requirements for energy and momentum resolution. Studying the ferromagnetic SC $UGe_2$ we demonstrate that for ferromagnetic QPTs this problem may be overcome using longitudinal modulation of intensity with zero effort (MIEZE) at the instrument RESEDA. In the case of $UGe_2$, we reveal purely longitudinal spin fluctuations with a dual nature arising from 5f electrons that are hybridized with the conduction electrons. Local spin fluctuations are perfectly described by the Ising universality class in three dimensions, whereas itinerant spin fluctuations occur over length scales comparable to the superconducting coherence length, showing that MIEZE is able to spectroscopically disentangle the complex low-energy behavior characteristic of quantum materials.

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