Spinning superconductors and ferromagnets

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When a magnetic field is applied to a ferromagnetic body it starts to spin (Einstein-de Haas effect). This demonstrates the intimate connection between the electron's magnetic moment $\mu_B = e\hbar/2m_e c$, associated with its spin angular momentum $S = \hbar/2$, and ferromagnetism. When a magnetic field is applied to a superconducting body it also starts to spin (gyromagnetic effect), and when a normal metal in a magnetic field becomes superconducting and expels the magnetic field (Meissner effect) the body also starts to spin. Yet according to the conventional theory of superconductivity the electron's spin only role is to label states, and the electron's magnetic moment plays no role in superconductivity. Instead, within the unconventional theory of hole superconductivity [1], the electron's spin and associated magnetic moment play a fundamental role in superconductivity. Just like in ferromagnets the magnetization of superconductors is predicted to result from an aggregation of magnetic moments with angular momenta $\hbar/2$ [2]. This gives rise to a "Spin Meissner effect" [3], the existence of a spin current in the ground state of superconductors. The theory explains how a superconducting body starts spinning when it expels magnetic fields [4], which we argue cannot be explained by the conventional theory, it provides a dynamical explanation for the Meissner effect [5], which we argue the conventional theory cannot do, and it explains how supercurrents stop without dissipation [6], which we argue the conventional theory fails to explain. Essential elements of the theory of hole superconductivity are that superconductivity is driven by lowering of kinetic energy [7], which we have also proposed is true for ferromagnets [8], that the normal state charge carriers in superconducting materials are holes, and that the spin-orbit interaction plays a key role in superconductivity. The theory is proposed to apply to all superconductors [9].

References:

[1] http://physics.ucsd.edu/~jorge/hole.html.
[2] J.E. Hirsch, Europhys. Lett. **113**, 37001 (2016).
[3] J.E. Hirsch, Europhys. Lett. **81**, 67003 (2008).
[4] J.E. Hirsch, Phys. Rev. B **95**, 014503 (2017).
[5] J.E. Hirsch, Physica Scripta **91**, 035801 (2016).
[6] J.E. Hirsch, Europhys. Lett. **114**, 57001 (2016).
[7] J.E. Hirsch, Int. J. Mod. Phys. B bf 25, 1173 (2011).
[8] J.E. Hirsch, Physica C **341-348**, 211 (2000).
[9] J.E. Hirsch, Physica C **472**, 78 (2012).