Magnetism and Superconductivity

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In these several decades, a lot of important theoretical and experimental approaches have been performed for understanding the itinerant-electron magnetism and superconductivity. Among them epoch-making was the great success of the spin-fluctuation theory for weak itinerant ferro- and antiferromagnets based on the self-consistent renormalization of spin fluctuations to magnetic free energy since 1973 (the SCR theory), exceeding the Stoner mean field theory and the dynamical mean field theory, called the random phase approximation (RPA) theory. Afterwards, the spin fluctuation theory has been developed toward the unified theory between the weakly itinerant ferro- and antiferromagnetic regime and the localized moment regime in metallic magnets by a phenomenological method. Furthermore, the itinerant-electron theory of spin fluctuations has been developed and rearranged in a quantitative way as well as by utilizing different approaches, by which we can compare the experiments and spin-fluctuation theories quantitatively by means of a set of spin-fluctuation parameters [1].

Meanwhile the novel superconductors have been discovered in the strongly correlated electron systems, such as heavy-fermion compounds and intermetallics, the organic compounds, the high-*Tc* cuprates, pyrochlore compounds, Co oxides with triangular lattices, Fe pnictides, and so on. Therefore, the correlations and interplays between the itinerant magnetism and the novel superconductivity, called exotic superconductivity, have been one of the most important problems in the solid-state sciences. The formalism of the BCS mean field theory should be valid even in high-T_c cuprate and iron pnictide superconductors, as well as in other strongly correlated electron superconductors, although the mediation mechanism of Cooper pairs should be different from that of BCS theory. In high-T_c cuprates, microscopic experiments have shown that the magnetic excitations were crucial, leading to the possible mechanism involving magnetic interaction-mediated Cooper pairs. In the spin-fluctuation theory, furthermore, the superconducting transition temperatures T_c of these exotic superconductors have been found to

scale universally by the characteristic temperature corresponding to the energy width of spin fluctuations, T_0, in exotic superconductors [1].

In this talk, the recent developments of experiments and theories in itinerant-electron magnetism and exotic superconductivity will be introduced and explained, and the future progresses as well as their applications will be discussed though in the author's personal views.

[1] Kazuyoshi Yoshimura, *J. Phys.: Conf. Series* **868**, 012001/1-8 (2017), and references therein.