Superconductivity in iron silicide $Lu_2Fe_3Si_5$ probed by radiation-induced disordering

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Resistivity $\rho(T)$, Hall coefficient $R_H(T)$, superconducting temperature T_c, and the slope of the upper critical field $-dH_{c2}/dT$ were studied in poly- and single-crystalline samples of the Fe-based superconductor $Lu_2Fe_3Si_5$ irradiated by fast neutrons. Atomic disordering induced by the neutron irradiation leads to a fast suppression of T_c similarly to the case of doping of $Lu_2Fe_3Si_5$ with magnetic (Dy) and nonmagnetic (Sc, Y) impurities. The same effect was observed in a novel FeAs-based superconductor La(O-F)FeAs after irradiation. Such behavior is accounted for by strong pair breaking that is traceable to scattering at nonmagnetic impurities or radiation defects in these unconventional superconductors. In such superconductors, the sign of the order parameter changes between the different Fermi sheets ($s^{\pm}$ model). Some relations that are specified for the properties of the normal and superconducting states in high-temperature superconductors are also observed in $Lu_2Fe_3Si_5$. The first is the relationship $-dH_{c2}/dT \sim T_c$, which allows us to assign the compound $Lu_2Fe_3Si_5$ to type II superconductors in the clean limit. The second is a correlation between the low-temperature linear coefficient a in the resistivity $\rho = \rho_0 + a_1 T$, which appears presumably due to the scattering at magnetic fluctuations, and T_c, this correlation being an evidence of a tight relation between the superconductivity and magnetism. Data point to an unconventional (nonphononic) mechanism of superconductivity in $Lu_2Fe_3Si_5$ and probably in some other Fe-based compounds, which can be fruitfully studied via the radiation-induced disordering.

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I. INTRODUCTION

The discovery of high-temperature superconductivity in layered iron-based compounds[1] has stimulated active experimental and theoretical studies of these systems in view of the possibility of the Cooper pairing of charge carriers of anomalous type. Hence, a systematic study of the disordering effects in new superconductors is especially important.[2] According to the Anderson theorem,[3] nonmagnetic impurities do not cause a suppression of the superconductivity in the case of a conventional *s*-type isotropic pairing. If the singlet pairing is traceable to the exchange of spin excitations, the requirement for this is the symmetry with a sign-changing order parameter.[4] Evidently, such requirement is fulfilled in high-T_c cuprates, where pairing with the *d*-wave symmetry is realized, while the pairing process is broken by the intraband scattering at nonmagnetic centers.[4–6] In the FeAs-based superconductors, the ordering parameter has the *s*-type symmetry. Therefore, a generally accepted model is the $s^{\pm}$ model, which treats a superconducting state with the opposite signs of the ordering parameter for electrons and holes.[4,7,8] In this case, nonmagnetic scatters must lead to the suppression of superconductivity due to the interband scattering between the electron- and hole-type Fermi surfaces.[4,5,9] Thus, the study of the atomic disordering in superconducting systems in which nonmagnetic scatters are generated allows one to reveal the symmetry of the ordering parameter.

Fast-neutron irradiation is the most effective method of atomic disordering, which was successfully applied earlier in investigation of a number of high-temperature superconductors. In the superconductors with strong electron-phonon interaction of the A-15 type, a decrease in the temperature of the superconducting transition T_c, as in Nb_3Sn or V_3Si (or increase in the T_c, as in Mo_3Si or Mo_3Ge), upon irradiation takes place because of decrease (increase) in density of states $N(E_F)$.[10] In the two-gap superconductor MgB_2, irradiation results in a relatively weak decrease of T_c,[10–12] which is largely due to the averaging of the gaps caused by the interband scattering at nonmagnetic impurities.[9] In the above examples, T_c remains finite upon radiation atomic disordering; the origin of such behavior is the electron-phonon nature of superconductivity in these compounds. Except for particular cases when disordering leads to localization of the charge carriers (the density of states of mobile carriers is equal to zero), in the majority of metallic systems $N(E_F)$, the width of superconducting gap remain finite upon atomic disordering and, consequently, T_c does not vanish.

In the Cu-based superconductors, such as $YBa_2Cu_3O_7$,[10,13–17] as well as the FeAs-based superconductors,[18–20] the fast and complete suppression of superconductivity under the high-energy particle irradiation, characteristic of the *d* pairing, most likely evidences a more exotic (nonphononic) pairing mechanism.

In the early '80s, several investigations were carried out to understand the superconductivity exhibited by compounds belonging to the $R_2Fe_3Si_5$ system.[21–24] These compounds crystallize in a tetragonal structure of the $Sc_2Fe_3Si_5$ type, consisting of a quasi-one-dimensional iron chain along the *c* axis and quasi-two-dimensional iron squares parallel to the basal plane. In $Lu_2Fe_3Si_5$, the superconductivity occurs at $T_c \sim 6.0$ K, which is exceptionally high among the Fe-based compounds other than the FeAs family. Moreover, a remarkable decrease of T_c by nonmagnetic impurities[25–27] also testifies to an unconventional origin of the superconductivity in these compounds.

This paper reports the results of studying the radiation-induced disordering effects on the properties of the superconducting and normal states of $Lu_2Fe_3Si_5$. It was expected that the irradiation defects, as well as impurities, such as Sc and Y, would create nonmagnetic scattering centers without substantial changes of the band structure. However, substitution of Lu with atoms of the same valences cannot produce a significant disorder (disorder appears in this case as a result of some lattice distortions in the vicinity of substituted sites), while the fast-neutron irradiation allows one to create defects with a much higher scattering ability and, hence, a stronger disorder can be gained. Studies of the states with a strong atomic disordering are of a paramount importance, since, judging from the observed (∼50%) decrease of T_c in experiments on doping, it is impossible to establish whether the superconductivity is fully suppressed, as in Cu- or Fe-based superconductors, or the T_c value remains finite, as in Nb_3Sn or MgB_2.

In the present study, our attention is focused on the effect of disordering on T_c and the slope of the upper critical field $-dH_{c2}/dT$, as well as their correlations with the normal-state properties, the disordering-induced changes in the crystal structure being beyond the scope of the work.

II. EXPERIMENTAL DETAILS AND RESULTS

Samples of $Lu_2Fe_3Si_5$ were prepared by arc melting stoichiometric amounts of high-purity elements. To improve the homogeneity of polycrystalline samples, they were annealed at 1200 °C for 19 hours. Single crystals 1.3 × 0.15 × 0.15 mm in size were obtained by annealing of the arc-melted ingot at 1720 °C for 2 hours.

The resistivity ρ and Hall coefficient R_H were measured using the standard four-point method with the reverse of the directions of the DC current and magnetic field and switching over between the current and potential leads.[28] The electric contacts were made by ultrasonic soldering with indium. Measurements were performed in the temperature range $T = 1.5$–380 K in magnetic fields up to 13.6 T. The polycrystalline samples were irradiated with fast neutrons with the fluence $\Phi = 2 \times 10^{19}$ cm^{-2} (for neutron energies $E_n >$ 0.1 MeV) at the irradiation temperature $T_{irr} = 50 \pm 10$ °C. The single-crystal samples were irradiated with the lower fluence $\Phi = 5 \times 10^{18}$ cm^{-2}. The samples of both types were annealed isochronally for 0.5 h in vacuum in the temperature range of $T_{ann} = 50$–1000 °C with a 50 °C step.

The irradiation to the fast-neutron fluence $\Phi = 2 \times 10^{19}$ cm^{-2} (polycrystalline samples) and $\Phi = 5 \times 10^{18}$ cm^{-2} (single crystals) suppresses the superconductivity and results in significant changes in the resistivity curves $\rho(T)$. Sequential annealings in the range of $T_{ann} = 100$–1000 °C lead to a practically complete restoration of the sample properties in both the normal and superconducting states.

Figures 1(a) and 1(b) show the temperature dependences of the resisitivity $\rho(T)$ for the polycrystalline and single crystal samples, respectively, representing pristine, irradiated, and annealed states. Both sets of data are very similar, taking into account the anisotropy of resistivity $\rho_a b/\rho_c \sim 4$,[27] whereas the percolation model[29] predicts that the ratio of the polycrystalline sample resistivity ρ to the single-crystal resistivity ρ_c must be $\rho/\rho_c \sim 2.7$.

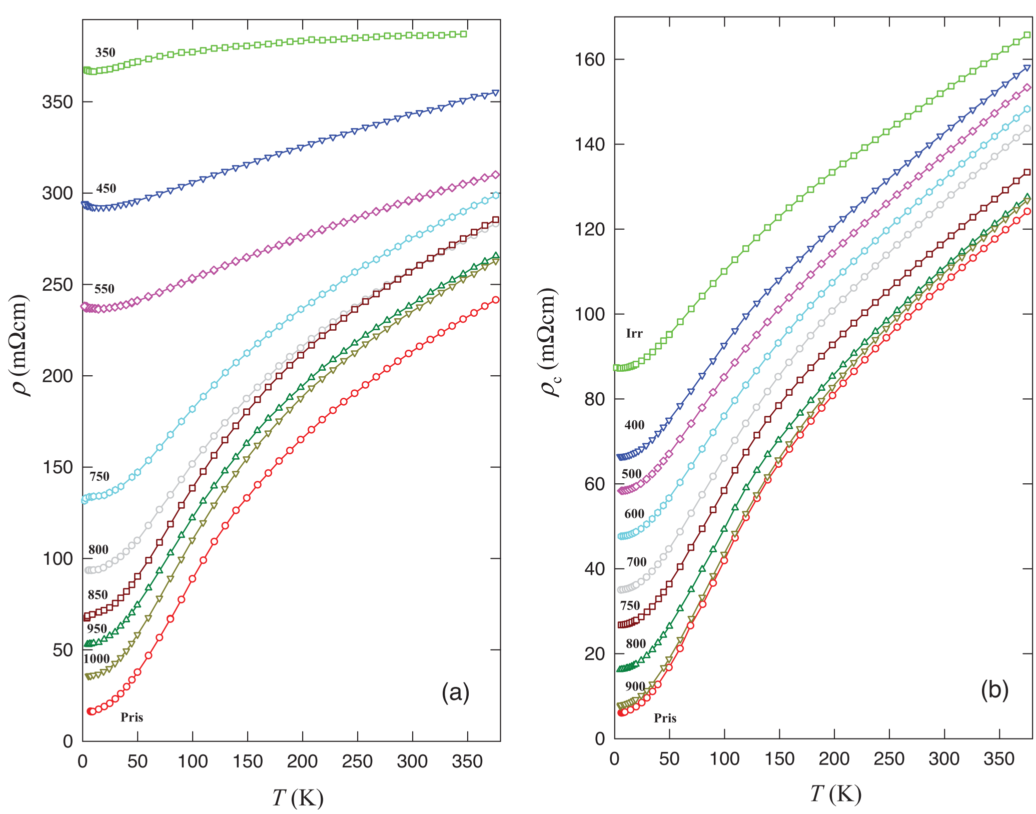

FIG. 1. (Color online) (a) Temperature dependences of the normal-state ($T > T_c$) resisitivity ρ for the pristine, irradiated to the neutron fluence $\Phi = 2 \times 10^{19}$ cm^{-2}, and annealed $Lu_2Fe_3Si_5$ polycrystalline samples. (b) Temperature dependences of the resistivity in the c direction ρ_c for the pristine, irradiated to the neutron fluence $\Phi = 5 \times 10^{18}$ cm^{-2}, and annealed $Lu_2Fe_3Si_5$ single crystals. Keys to curves: pristine sample (Pris), irradiated sample (Irr), digits denote annealing temperature in °C.

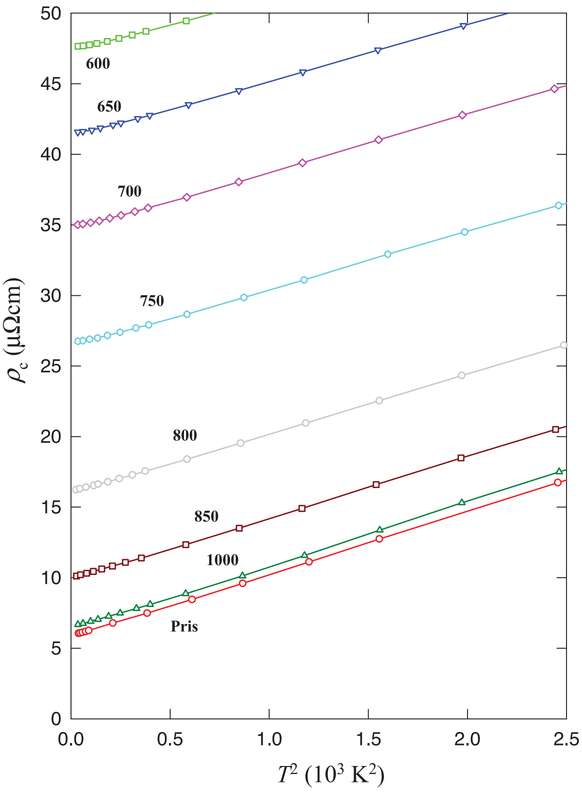

FIG. 2. (Color online) Resisitivity ρ as a function of T^2 for the $Lu_2Fe_3Si_5$ single crystal. Keys to curves are the same as in Fig. 1.

The slope $d\rho/dT$ at high temperatures $T = 100$–380 K decreases with increasing ρ_0. A similar saturation of the resistivity is observed in many strongly disordered metallic compounds, including many compounds irradiated by fast neutrons.[10]

In the temperature range $10 < T < 70$ K, the $\rho(T)$ curves for the single-crystal sample at low $\rho_0 = 5$–40 $\mu\Omega$ cm obey a quadratic law $\rho(T) = \rho_0 + a_2T^2$ with $a_2 \sim 4{\cdot}10^{-3}$ $\mu\Omega$ cm/K^2 (Fig. 2). When fitting curves with a power function $\rho(T) = \rho_0 + a_2T^k$, the index k varies within the limits from 2.02 to 2.12. Similar behavior is observed for the polycrystalline sample: a_2 is approximately constant at $\rho_0 = 5$–50 $\mu\Omega$ cm and slightly decreases with the further increase in ρ_0 (Fig. 1).

At lower temperatures $T < 10$ K, the resistivity curves are described better by linear functions $\rho(T) = a_0 + a_1T$ for the superconducting samples ($\rho_0 < 10$ $\mu\Omega$ cm, Fig. 3), while for the nonsuperconducting samples ($\rho_0 > 40$ $\mu\Omega$ cm), a small negative slope $d\rho/dT < 0$ is observed.

The Hall coefficient R_H for the pristine polycrystalline sample is relatively small and slightly temperature dependent, which is in agreement with the measurements of R_H on single crystals, as well as the data on the Fermi surfaces calculated for $Lu_2Fe_3Si_5$ by the full potential linearized augmented plane wave (FLAPW) method. The Fermi surface consists of two holelike bands and one electronlike band,[31] so that the hole and electronic contributions to the Hall coefficient are almost compensated. The irradiation does not lead to a considerable change in R_H (Fig. 4), which serves as a kind of evidence that there are no essential doping effects due to the disordering induced by the fast-neutron irradiation.

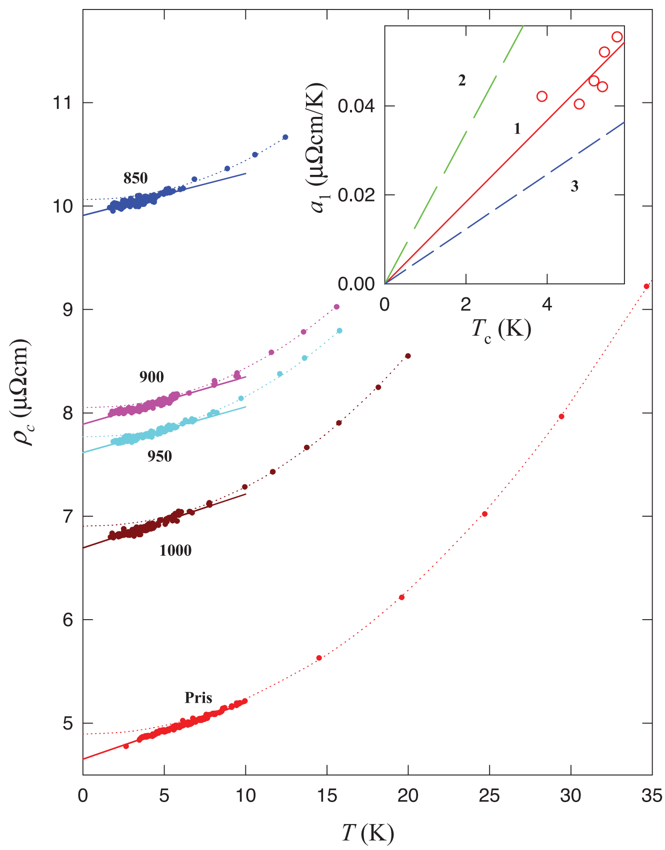

FIG. 3. (Color online) Temperature dependences of resistivity ρ_c for the $Lu_2Fe_3Si_5$ single crystal. Keys to curves are the same as in Fig. 1. The points are collected from the curves at $T > T_c$ in magnetic fields up to 13.6 T with the correction for magnetoresistance. Solid and dotted lines present a linear low-temperature and a quadratic high-temperature approximation, respectively. Inset shows the linear coefficient a_1 in the equation $\rho(T) = a_0 + a_1T$ as a function of T_c for (1) $Lu_2Fe_3Si_5$, (2) Fe-based system $Ba(Fe_{1-x}Co_x)_2As_2$, and (3) Cu-based system $Tl_2Ba_2CuO_{6+\delta}$ (Ref. 30).

Fig. 5 sums the results of annealing of the polycrystalline and single-crystal samples. The reduced resistivity ρ_0/ρ_{300}, which is a good measure of the electron mean-free path in $Lu_2Fe_3Si_5$,[27] shows a similar behavior in the single- and polycrystals as a function of the annealing temperature T_{ann}. The intensive recovery of ρ_0/ρ_{300} begins at $T_{ann} \geqslant 600$ °C only; the radiation defects still survive at relatively high annealing temperatures $T_{ann} \sim 900$ °C.

To compare the suppression of the superconductivity under irradiation with the results of doping with nonmagnetic impurities,[32–34] we have drawn T_c determined at 0.5 the normal-state resistivity as a function of the reduced resistivity ρ_0/ρ_{300} (Fig. 6), which does not depend on the sample quality (poly- or single crystal). With increasing ρ_0/ρ_{300}, the T_c value is seen to decrease similarly in both the irradiated and doped samples; it goes to zero at $\rho_0/\rho_{300} \approx 0.3$, which corresponds to $\rho_0 \approx 80$ and ≈ 40 $\mu\Omega$ cm for the polycrystalline and single-crystal samples, respectively. A common dependence of T_c on ρ_0/ρ_{300}, quite apparent at the starting portion $\rho_0/\rho_{300} \leqslant 0.15$, indicates that the only reason for the T_c decrease, both under irradiation and doping, is the appearance of scattering centers.

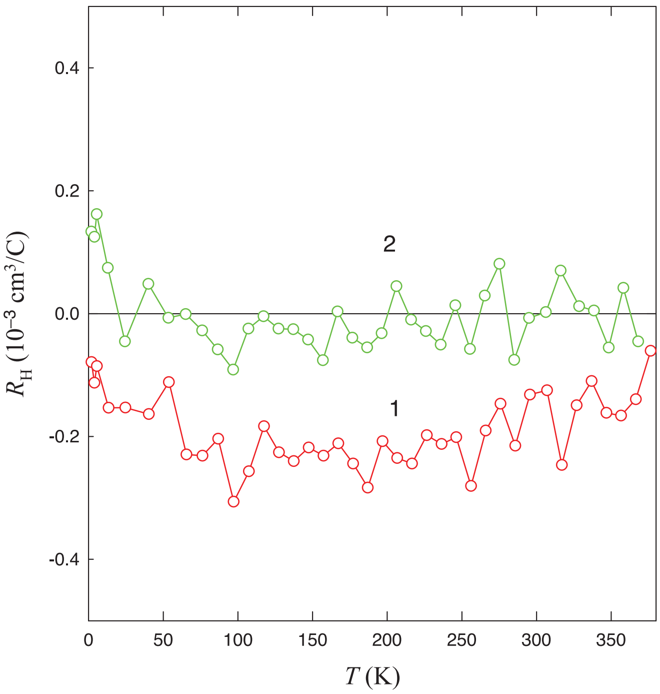

FIG. 4. (Color online) Temperature dependence of the Hall coefficient R_H for the $Lu_2Fe_3Si_5$ poly-cristaline sample: (1) pristine state and (2) irradiated and annealed at 75 °C.

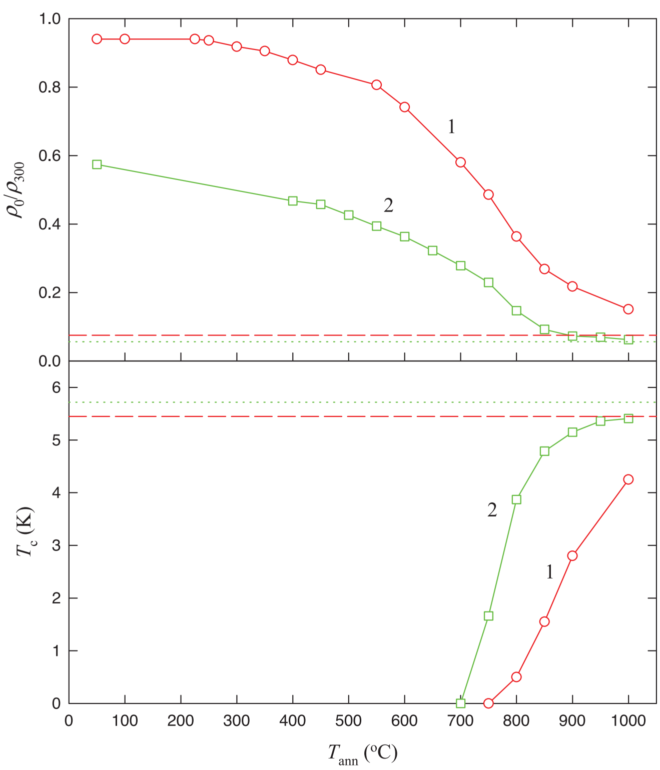

FIG. 5. (Color online) Reduced resistivity ρ_0/ρ_{300} and T_c as a function of annealing temperature T_{ann} for (1) polycrystalline and (2) single-crystal $Lu_2Fe_3Si_5$ samples, irradiated to fast-neutron fluence $\Phi = 2 \times 10^{19}$ cm^{-2} and $\Phi = 5 \times 10^{18}$ cm^{-2}, respectively. The dashed and dotted horizontal lines show the levels of ρ_0/ρ_{300} and T_c for the pristine polycrystalline and single-crystal samples, respectively.

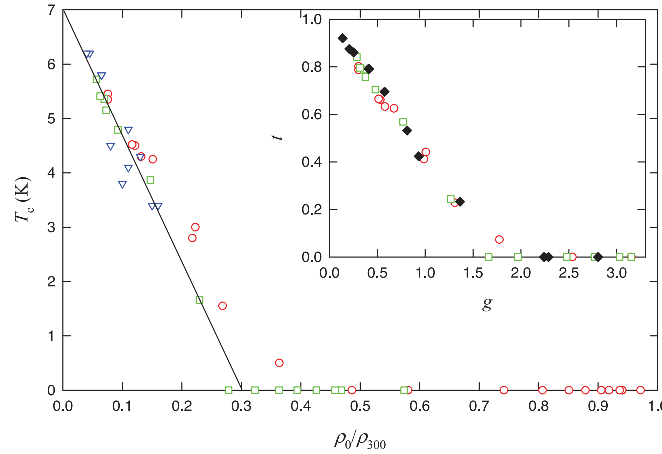

FIG. 6. (Color online) T_c as a function of ρ_0/ρ_{300} for the irradiated and annealed polycrystalline (○) and single-crystal (□) $Lu_2Fe_3Si_5$ samples and (Lu-R)$_2$Fe$_3$Si$_5$ (R = Y, Sc, Dy) single crystals (▽) (Ref. 27); straight line is drawn by eye. Inset shows $t = T_c/T_{c0}$ vs $g = \hbar/(2\pi k_B T_{c0}\tau)$ for the polycrystalline (○) and single-crystal (□) $Lu_2Fe_3Si_5$ samples and irradiated La(O-F)FeAs sample (◆) (Ref. 18).

For comparison with the theoretical models, we made use of the universal Abrikosov–Gor'kov (AG) equation describing the superconductivity suppression by magnetic impurities for the case of s pairing, and by nonmagnetic impurities (defects) for the case of d and $s^{\pm}$ pairing:[35–37]

$$\ln(1/t) = \psi(g/t + 1/2) - \psi(1/2), \tag{1}$$

where $g = \hbar/(2\pi k_B T_{c0}\tau) = t\xi_0/l$, ψ is the digamma function, $t = T_c/T_{c0}$, T_{c0} and T_c are the superconducting temperatures of the pristine and disordered systems, respectively, τ is the electronic relaxation time, $\xi_0 = (\hbar v_F)/(2\pi k_B T_c)$ is the coherent length, l is the mean-free path. Equation (1) describes the decrease of T_c as a function of the inverse relaxation time τ^{-1}; superconductivity is suppressed at $g > g_c = 0.28$. The dimensionless parameter g can be constructed from the experimental values:

$$g = (\hbar\rho_{0ab})/\left(2\pi k_B T_c \mu_0 \lambda_c^2\right), \tag{2}$$

where λ_c is the superconducting penetration depth, $\lambda_c = 0.2$ μm[38] for the pristine sample in the $H \| c$ orientation, ρ_{0ab} corresponds to the $J \| ab$ orientation.

The inset in Fig. 6 shows the $t = T_c/T_{c0}$-vs-g dependences calculated using Eq. (2) with $\rho_{0ab} = 4\rho_{0c}$[27] for the single cryatals and the percolation relationship $\rho_{0ab} = 4\rho_0/2.7$ for the polycrystals. The quantity t goes to zero at $g \approx 1.5$, which is 5 times as large as the AG value $g_c = 0.28$. A very similar decrease of t vs g was found in the neutron-irradiated novel Fe-based compound La(O-F)FeAs (Fig. 6),[18] α-irradiated Nd(O-F)FeAs,[19] and proton-irradiated Ba(Fe$_{1-x}$Co$_x$)$_2$As$_2$.[20]

There are a number of uncertainties in the identification of the scattering centers contributing to the resistivity ρ_0. In the $s^{\pm}$-pairing model, Eq. (1), only the interband scattering at nonmagnetic impurities is taken into account, which is not easily separated from the other contributions (intraband scattering, magnetic scattering, etc.). Nevertheless, the AG model significantly overestimates the T_c decrerase in $Lu_2Fe_3Si_5$ and probably in other Fe-based superconductors.

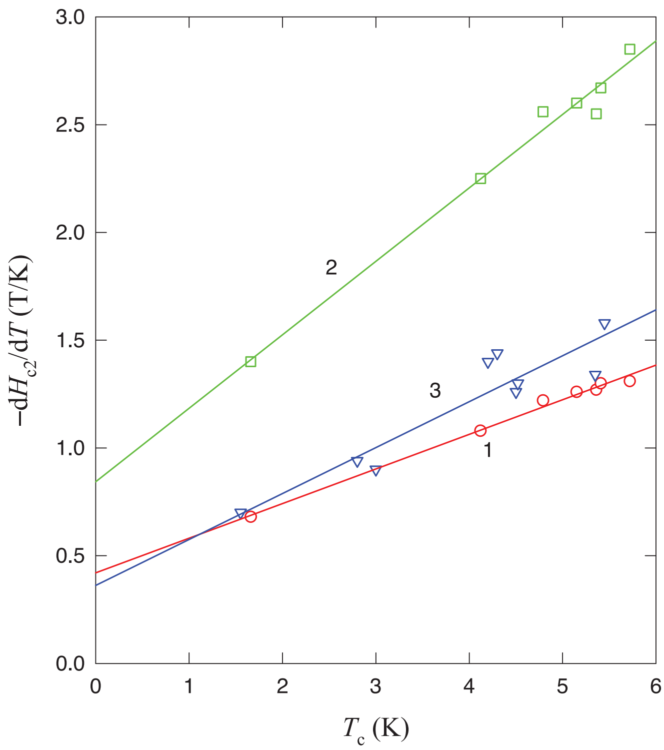

FIG. 7. (Color online) The slope of the upper critical field $-dH_{c2}/dT$ as a function of T_c for the irradiated and annealed $Lu_2Fe_3Si_5$ samples. (1) and (2) single crystal, H is parallel to the ab and c directions, respectively; (3) polycrystalline sample.

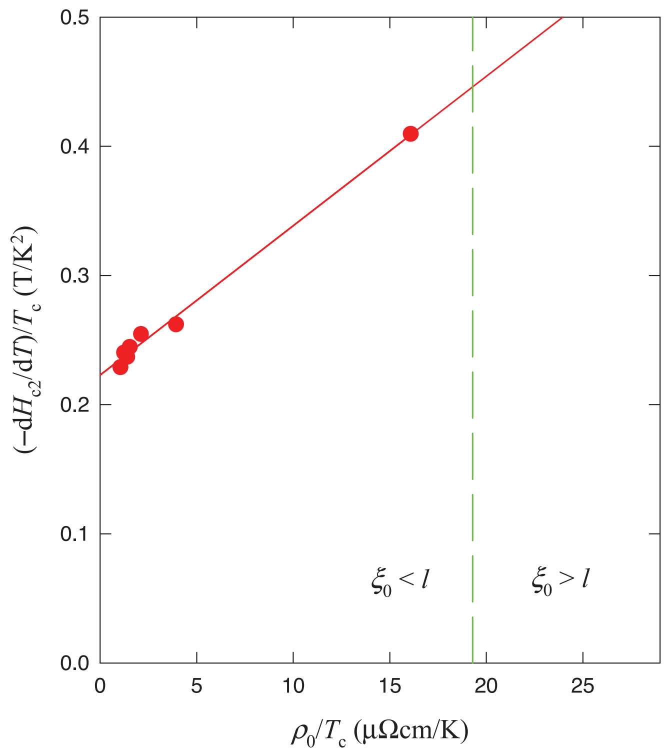

FIG. 8. (Color online) $(-dH_{c2}/dT)/T_c$ ($H \| ab$) as a function of ρ_0/T_c for the irradiated and annealed $Lu_2Fe_3Si_5$ single crystal. Straight line is the mean square fitting.

Figure 7 shows the slope of the upper critical field $-dH_{c2}/dT$ determined at 0.9 the normal-state resistivity as a function of T_c for the irradiated and annealed $Lu_2Fe_3Si_5$ polycrystalline and single-crystal samples. The relationship $(-dH_{c2}/dT)_c \approx 2(-dH_{c2}/dT)_{ab}$ holds well for all superconducting crystals, which evidences that the topology of the Fermi surface is not significantly changed by irradiation.

The observed behavior can be roughly approximated by a linear dependence. The similar behavior features many FeAs-based compounds.[39] It is worth mentioning that $-dH_{c2}/dT \sim T_c$ is predicted for type II superconductors in the clean limit, while in the dirty limit, the opposite dependence $-dH_{c2}/dT \sim \rho_0$ (that is, the $-dH_{c2}/dT$ growth upon decreasing T_c) takes place.

The estimation of $g = t\xi_0/l$ has shown (Fig. 6) that the superconducting samples belong to the clean ($\xi_0 \ll l$) or the intermediate ($\xi_0 \approx l$) limit for the samples with $T_c \approx 5$ K or $T_c \approx 1.5$ K, respectively. In the expression for the slope of the upper critical field $-dH_{c2}/dT = \phi_0/(0.69 \times 2\pi\xi^2 T_c)$, the coherent length ξ can be written in the intermediate limit as

$$1/\xi^2 \approx (1/\xi_0)(1/\xi_0 + 1/l), \quad (3)$$

and, hence, dH_{c2}/dT depends on T_c and ρ_0 as

$$-dH_{c2}/dT \approx c_1 T_c \rho_0. \quad (4)$$

Figure 8 shows such dependence in the coordinates $(-dH_{c2}/dT)/T_c$ as a function of ρ_0/T_c. In the limit $\rho_0/T_c \to 0$, the intercept gives the coherent length $\xi = \xi_0$ in the clean limit ($\xi_{0c} \approx 100$ Å, $\xi_{0ab} \approx 50$ Å). According to Eqs. (3) and (4), at the doubled intersect, we get $\xi_0 = l$ (vertical line in Fig. 8).

According to Fig. 8, the ration $\xi_0/l = g/t = 1$ in the single-crystal sample corresponds to $\rho_0 \sim 30\ \mu\Omega$ cm, $T_c \sim 1.5$ K. This is in a qualitative agreement with the estimation of g according to Eq. (2); $g = t$ (Fig. 6) corresponds to $\rho_0 \sim 15\ \mu\Omega$ cm, $T_c \sim 4$ K.

Thus, our estimations of the relation between ξ_0 and l clearly show that the pristine $Lu_2Fe_3Si_5$ samples with $T_c \approx 5$ K are ascribed to the clean limit $\xi_0 \ll l$. On the other hand, these estimations are in a visual disagreement with the relation between the anisotropy of resistivities ρ_{ab}/ρ_c and slopes of the upper critical field $(dH_{c2}/dT)_c/(dH_{c2}/dT)_{ab} = \xi_c/\xi_{ab}$. In the clean limit, $\xi_{ab,c} \approx (\xi_0)_{ab,c}$, and, hence, the anisotropy of the upper critical field is proportional to ρ_{ab}/ρ_c, while in the dirty limit, $\xi_{ab,c} \approx [(\xi_0 l)_{ab,c}]^{1/2}$, and the anisotropy of the upper critical field is proportional to $(\rho_{ab}/\rho_c)^{1/2}$. As it was mentioned above, the anisotropy of the upper critical field for the single crystal in the pristine, irradiated, and annealed states is close to two. The anisotropy of the resistivities (in the pristine sample) ρ_{ab}/ρ_c is approximately equal to four,[27] which means that the state is closer to the dirty limit. On the other hand, estimations of l, using the values of ρ_0 and low-temperature Hall coefficient R_H reported in Ref. 27, yield for the pristine sample $\xi_{ab} \sim 50$ Å and $l_{ab} \sim 200$ Å, which allows the sample state to be referred to the clean limit; however, such estimations for many-band systems are invalid. Another way of estimating l is to employ the data for the strongly disordered sample in which ρ weakly depends on temperature $\rho \sim \rho_{sat}$. Assuming that in this region l has a value of the order of atomic spacing $d \sim 5$ Å, one can independently estimate l based on the relationship $\rho_{0c} \sim \rho_{sat}(d/l)$. Specifying for the single-crystal sample $\rho_{sat} \sim 250\ \mu\Omega$ cm, we obtain for the pristine sample the value $\rho_{0c} \sim 5\ \mu\Omega$ cm and $l_c \sim 250$ Å, which again are assigned to the clean limit. Obviously, to resolve the contradiction, direct measurements are necessary, which were impossible to perform in our crystals because of a too large ($\sim$10) ratio of the sample dimensions in the directions c and a.

Similar estimations can be made for the parameter $g = t\xi_{0c}/l_c$. They show that the superconductivity disappears at $g \sim 2$ in agreement with the estimates of g by Eq. (2) (inset in Fig. 6). However, this estimate, just as the previous ones, is rather rough and unsuitable for such many-band systems as $Lu_2Fe_3Si_5$. Yet, with allowance for all possible uncertainties in the estimation of g, the AG model predicts a markedly faster degradation of superconductivity than is observed in experiments.

Returning to the correlation between the linear term in resistivity a_1 and T_c (inset in Fig. 3), it is worth mentioning that the relation $T_c \sim a_1$ is an attribute of many unconventional superconductors. The T_c-vs-a_1 correlation is very close to that observed for the Fe- and Cu-based high-T_c superconductors. This correlation does not seem evident in our case of the irradiated $Lu_2Fe_3Si_5$ sample, since the a_1 term in the low-T resistivity is significantly masked by the logarithmic term for the samples with $T_c \leqslant 3$ K. On the other hand, at $T > 10$ K, the quadratic term dominates, since the linear term for $Lu_2Fe_3Si_5$ is much less than that for high-T_c superconductors, which is due to the low value of $T_c \sim 6$ K in $Lu_2Fe_3Si_5$ in comparison with $T_c \sim 100$ K in high-T_c superconductors. When fitting the curves with the power function $\rho(T) = \rho_0 + a_1T^k$, the index k varies in the range 1.0–1.4, which noticeably differs from that for the quadratic dependence (Fig. 3). In any case, the presence of a quasilinear term in the low-temperature electrical conductivity is beyond question.

The linear-in-T resistivity can be explained by the existence of two-dimensional AF spin fluctuations in the theory of nearly AF metals.[40,41] The AF fluctuations are enhanced significantly near the AF phase in optimally doped high-T_c superconductors, where the temperature dependence of the resistivity changes from the T^2 to T law. In $Lu_2Fe_3Si_5$, with the lower T_c, the linear term is meaningful only at low $T < 10$ K (Fig. 3), while at higher $10 < T < 70$ K, the T^2 term predominates (Fig. 2).

III. CONCLUSIONS

In conclusion, our results show the fast decrease of the superconducting temperature T_c in the $Lu_2Fe_3Si_5$ samples under fast-neutron irradiation. The uniform dependence of T_c on the residual resistivity ρ_0 for the case of both irradiation and doping evidences that the decrease in T_c is due to the presence of nonmagnetic scattering centers. The slow changes in the Hall coefficient R_H and $(dH_{c2}/dT)_c/(dH_{c2}/dT)_{ab}$ show that there are no substantial changes in the topology of the Fermi surface caused by irradiation.

The superconductivity disappears when the coherent length ξ_0 becomes larger than the mean-free path l, $g = t\xi_0/l > 1$. Such behavior is very similar to that observed in FeAs-based superconductors, but the T_c decrease is $\sim$5 times as slow as that predicted based on the Abrikosov–Gor'kov equation, which describes the superconductivity suppression by nonmagnetic impurities (defects) for the case of d and $s^\pm$ pairing.

Our estimations show that the observed correlation of T_c with the slope of the upper critical field $-dH_{c2}/dT$ in the irradiated polycrystalline and single-crystal $Lu_2Fe_3Si_5$ samples (and probably in other Fe-based superconductors) has a trivial origin: by their state, the superconducting samples belong to the clean $\xi_0 \ll l$ (at worst, to the intermediate $\xi_0 \approx l$) limit.

The observed correlation of the liner term a_1 in the resistivity $\rho(T) = a_0 + a_1T$ with T_c testify to the significance of spin fluctuations in the formation of the superconducting state in $Lu_2Fe_3Si_5$.

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