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Comment on "Superconductivity in Kagome Metal YRu_3Si_2 with Strong Electron Correlations"

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Recently, Gong *et al.* [*Chin. Phys. Lett.* 39 087401 (2022)] reported the results of a detailed study of the physical properties of high-quality YRu_3Si_2 single crystals with the Ru kagome lattice in the normal and superconducting states. One of the reported parameters, the ground-state penetration depth, $\lambda_{GL}(0, l)$ = 24.8 nm, was deduced from the lower critical field, $H_{c1}(T, l)$. From the deduced $\lambda_{GL}(0, l)$, the authors calculated the ground-state values for the Ginzburg-Landau parameter $\kappa_{GL}(0, l)$=1.11 and the thermodynamic critical field $B_c(0, l)$ = 0.42 T. Here I argue that the reported values of $\lambda_{GL}(0, l)$, $\kappa_{GL}(0, l)$, and $B_c(0, l)$ are incorrect since the equation for the lower critical field $H_{c1}(T, l)$, used by the authors to derive $\lambda_{GL}(0, l)$, is invalid as it has two roots. Correct values deduced from the experimental data reported by Gong *et al.* are $\lambda_{GL}(0, l)$ = 110.4 nm, $\kappa_{GL}(0, l)$ = 4.92, and $B_c(0, l)$ = 0.094 T, which differ by a factor of 4.5 from reported values.

Ground-state London penetration depth, $\lambda(0)$, is one of the primary parameters of any superconductor, which relates to the charge carrier density $n_e(0)$ in the conductor by the equation [1,2]:

$$n_e(0) = \frac{m_e}{\mu_0 e^2 \lambda^2(0)}, \tag{1}$$

where m_e is the mass of the charge carrier, μ_0 is the magnetic permeability of free space, e is the electron charge. However, Eq. (1) is valid in the clean-limit condition, when the mean-free path (MFP), l, of the charge carrier significantly exceeds the fundamental Bardeen–Cooper–Schrieffer (BCS) coherence length, ξ_0 [3]:

$$\frac{\xi_0}{l} \ll 1, \tag{2}$$

$$\xi_0 = \frac{\hbar v_F}{\pi \Delta(0)}, \tag{3}$$

where $\hbar$ is the reduced Planck constant, v_F is the Fermi velocity, and $\Delta(0)$ is the amplitude of the ground-state superconducting gap. The MFP can be calculated within the Fermi gas model [4–6] as a product of the Fermi velocity v_F and the scattering time τ [6,7]:

$$\begin{aligned} l = v_F \times \tau &= \sqrt[3]{\frac{3}{8\pi}} \times \frac{h}{e^2} \times \frac{1}{\rho_0 \times n_e^{2/3}} \\ &= \sqrt[3]{\frac{3}{8\pi}} \times R_K \times \frac{1}{\rho_0 \times n_e^{2/3}}, \end{aligned} \tag{4}$$

where h is the Planck constant, $\rho_0 \equiv \rho(T \to 0\,\mathrm{K})$ is the residual resistivity, and $R_K = h/e^2 = 25,813\,\Omega$ is the von Klitzing constant [8].

There is a very rare case when Eq. (2) is satisfied for real-world samples. Instead, there is a more common case when [9–11]

$$0.3 \leqslant \frac{\xi_0}{l}. \tag{5}$$

And within the framework of the Ginzburg–Landau theory [4], the equations for the ground-state values for real-world superconducting samples are [4,12,13]

$$\lambda_{GL}(0,l) = \lambda_L(0) \times \sqrt{1 + \frac{\xi_0}{l}}, \tag{6}$$

$$\xi_{GL}(0,l) = \frac{\pi}{2\sqrt{3}} \times \xi_0 \times \frac{1}{\sqrt{1 + \frac{\xi_0}{l}}}, \tag{7}$$

$$\kappa_{GL}(0,l) = \frac{\lambda_{GL}(0,l)}{\xi_{GL}(0,l)}. \tag{8}$$

There are standard techniques to determine the Ginzburg–Landau penetration depth, $\lambda_{GL}(T,l)$, and the Ginzburg–Landau coherence length, $\xi_{GL}(T,l)$ [14,15]. These methods are the approximation of the following equations to the measured datasets of the lower and upper critical fields, $\mu_0 H_{c1}(T,l)$ and $\mu_0 H_{c2}(T,l)$, respectively:

$$\begin{aligned} \mu_0 H_{c1}(T,l) &= \frac{\phi_0}{4\pi} \frac{\ln\left(\frac{\lambda_{GL}(T,l)}{\xi_{GL}(T,l)}\right) + \delta(\kappa_{GL}(T))}{\lambda^2_{GL}(T,l)} \\ &\cong \frac{\phi_0}{4\pi} \frac{\ln\left(\frac{\lambda_{GL}(0,l)}{\xi_{GL}(0,l)}\right) + \delta(\kappa_{GL}(0,l))}{\lambda^2_{GL}(T,l)}, \end{aligned} \tag{9}$$

where $\delta(\kappa_{GL})$ is given by [15]

$$\begin{aligned} \delta(\kappa_{GL}(T,l)) &= 0.5 + \frac{1 + \ln(2)}{2\kappa_{GL}(T,l) + 2 - \sqrt{2}} \\ &\cong 0.5 + \frac{1 + \ln(2)}{2\kappa_{GL}(0,l) + 2 - \sqrt{2}}, \end{aligned} \tag{10}$$

$$\begin{aligned} \mu_0 H_{c2}(T,l) &= \frac{\phi_0}{2\pi \xi^2_{GL}(T,l)} \\ &= \frac{\phi_0}{2\pi \xi^2_{GL}(0,l)} \times \left(\frac{1 - \left(\frac{T}{T_c}\right)^2}{1 + 0.42 \times \left(\frac{T}{T_c}\right)^{1.47}} \right), \end{aligned} \tag{11}$$

where the right-hand side of Eq. (11) is an analytical approximation proposed by Prozorov and Kogan [16] for the Werthamer-Helfand-Hohenberg (WHH) upper critical field model [17,18]. For completeness, it should be mentioned that the thermodynamic critical field is given by the following equation:

$$\mu_0 H_c(T,l) = \frac{\phi_0}{2\sqrt{2}\pi \xi_{GL}(T,l) \lambda_{GL}(T,l)}. \tag{12}$$

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The major problem with using Eq. (9) is that for any given values of $\xi_{GL}(T,l)$ and $\mu_0 H_{c1}(T,l)$ there are two $\lambda_{GL}(T,l)$ roots [19,20]. To resolve this problem, the following equation, which has a single unique $\lambda_{GL}(T,l)$ root for any given of $\xi_{GL}(T,l)$ and $\mu_0 H_{c1}(T,l)$ values was proposed [21]:

$$\mu_0 H_{c1}(T,l) = \frac{\phi_0}{4\pi}\frac{\ln\left(1+\sqrt{2}\times\frac{\lambda_{GL}(T,l)}{\xi_{GL}(T,l)}\right)}{\lambda^2_{GL}(T,l)} \cong \frac{\phi_0}{4\pi}\frac{\ln\left(1+\sqrt{2}\times\frac{\lambda_{GL}(0,l)}{\xi_{GL}(0,l)}\right)}{\lambda^2_{GL}(T)}. \quad (13)$$

Gong *et al.* [22] used a very approximate equation for the lower critical field

$$\mu_0 H_{c1}(T,l) = \frac{\phi_0}{4\pi}\frac{\ln\left(\frac{\lambda_{GL}(T,l)}{\xi_{GL}(T,l)}\right)}{\lambda^2_{GL}(T,l)} \cong \frac{\phi_0}{4\pi}\frac{\ln\left(\frac{\lambda_{GL}(0,l)}{\xi_{GL}(0,l)}\right)}{\lambda^2_{GL}(T,l)}, \quad (14)$$

which also has the problem of two $\lambda_{GL}(0,l)$ roots for any given values of $\xi_{GL}(T,l)$ and $\mu_0 H_{c1}(T,l)$ [19,20,23].

In the result, Gong *et al.*[22] reported the smallest of two $\lambda_{GL}(0,l)$ roots (for instance, $\lambda_{GL}(0,l) = 24.8$ nm) while the correct $\lambda_{GL}(0,l)$ value can be deduced by the use of Eq. (13), which has a unique root:

$$\lambda_{GL}(0,l) = 110.4\ \text{nm}, \quad (15)$$

$$\mu_0 H_{c1}(T\to 0\,\text{K},l) = 2.80\times10^{-2}\,\text{T} = \frac{\phi_0}{4\pi}\frac{\ln\left(1+\sqrt{2}\times\frac{\lambda_{GL}(0,l)}{\xi_{GL}(0,l)}\right)}{\lambda^2_{GL}(T\to 0\,\text{K})} = \frac{2.067\times10^{-15}\,\text{Wb}}{4\times3.1415}\times\frac{\ln\left(1+\sqrt{2}\times\frac{1.104\times10^{-7}\,\text{m}}{2.243\times10^{-8}\,\text{m}}\right)}{(1.104\times10^{-7}\,\text{m})^2}, \quad (16)$$

where I used the value of $\xi_{GL}(0,l) = 22.43$ nm, which was correctly deduced from the $\mu_0 B_{c2}(T,l)$ data by Gong *et al.*[22].

In the result, the following ground-state superconducting parameters in the kagome metal YRu_3Si_2 can be calculated:

$$\kappa_{GL}(0,l) = \frac{\lambda_{GL}(0,l)}{\xi_{GL}(0,l)} = \frac{1.104\times10^{-7}\,\text{m}}{2.243\times10^{-8}\,\text{m}} = 4.92, \quad (17)$$

$$\mu_0 H_c(0,l) = \frac{\phi_0}{2\sqrt{2}\pi\xi_{GL}(0,l)\lambda_{GL}(0,l)} = \frac{2.067\times10^{-15}\,\text{Wb}}{2\sqrt{2}\times3.1415\times(2.243\times10^{-8}\,\text{m})\times(1.104\times10^{-7}\,\text{m})} = 9.4\times10^{-2}\,\text{T}. \quad (18)$$

The deduced $\lambda_{GL}(0,l) = 110$ nm [Eq. (15)] is in reasonable agreement with the recently reported value of $\lambda_{GL}(0,l) = 173$ nm by Král *et al.* [24] in YRu_3Si_2. The difference in $\lambda_{GL}(0,l)$ values can be explained by the difference in the mean-free path of the charge carriers l in samples fabricated by Gong *et al.* [22] and Král *et al.* [24] [see Eq. (6)].

It should be noted that other key physical parameters of the high-quality YRu_3Si_2 single crystals reported by Gong *et al.* [22] (for instance, the Kadowaki–Woods ratio A/γ^2, the Wilson ratio R_W, the relative jump in electronic specific heat at the transition temperature $\Delta C_{el}/\gamma T_c$, and the electron–phonon coupling constant λ_{e-ph}) remain unchanged.

In conclusion, I have described in as much detail as possible the procedure for deriving the ground-state penetration depth, $\lambda_{GL}(0,l)$, the Ginzburg–Landau parameter, $\kappa_{GL}(0,l)$, and the thermodynamic critical field, $\mu_0 H_c(0,l)$, from the measured $\mu_0 H_{c1}(T,l)$ and $\mu_0 H_{c2}(T,l)$ datasets.

Data Availability Statement

The data that supports the findings of this study is available from the corresponding author upon reasonable request.

Declaration of Interests

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] London H and London F 1935 *Proc. R. Soc. Lond. A Math. Phys. Sci.* **149** 71
[2] Poole C P, Farach H, Creswick R, and Prozorov R 2007 *Superconductivity* (London, UK: Academic Press)
[3] Bardeen J, Cooper L N, and Schrieffer J R 1957 *Phys. Rev.* **108** 1175
[4] Mayoh D A, Barker J A T, Singh R P, Balakrishnan G, Paul D M, and Lees M R 2017 *Phys. Rev. B* **96** 064521
[5] Singh D, Sajilesh K P, Marik S, Hillier A D, and Singh R P 2019 *Phys. Rev. B* **99** 014516
[6] Sondheimer E H 2001 *Adv. Phys.* **50** 499
[7] Poole C P 2000 *Handbook of Superconductivity* p. 29
[8] Klitzing K V, Dorda G, and Pepper M 1980 *Phys. Rev. Lett.* **45** 494
[9] Uemura Y J 1997 *Hyperfine Interact.* **105** 35
[10] Uemura Y J 1991 *Physica C Supercond.* **185-189** 733
[11] Le L P, Luke G M, Sternlieb B J, Wu W D, Uemura Y J, Brill J W, and Drulis H 1991 *Physica C Supercond.* **185-189** 2715
[12] Mayoh D A, Holt S J R, Takabatake T, Balakrishnan G, and Lees M R 2021 *Phys. Rev. Mater.* **5** 114803
[13] Tinkham M 2004 *Introduction to Superconductivity* (Mineola, New York, USA: Dover Publications)
[14] Brandt E H 2011 *Phys. Status Solidi B* **248** 2305
[15] Brandt E H 2003 *Phys. Rev. B* **68** 054506
[16] Prozorov R and Kogan V G 2024 *Phys. Rev. Appl.* **22** 064006
[17] Helfand E and Werthamer N R 1966 *Phys. Rev.* **147** 288
[18] Werthamer N R, Helfand E, and Hohenberg P C 1966 *Phys. Rev.* **147** 295
[19] Talantsev E F 2021 *J. Appl. Phys.* **130** 195901
[20] Talantsev E F 2023 *J. Appl. Phys.* **134** 179901
[21] Talantsev E F 2018 *Mod. Phys. Lett. B* **32** 1850114
[22] Gong C, Tian S, Tu Z, Yin Q, Fu Y, Luo R, and Lei H 2022 *Chin. Phys. Lett.* **39** 087401
[23] Talantsev E F 2024 *Supercond. Sci. Technol.* **37** 128001
[24] Král P, Graham J N, Sazgari V, Plokhikh I, Lukovkina A, Gerguri O, Biało I, Doll A, Martinelli L, Oppliger J, Islam S S, Spitaler M, Wang K, Salamin M, Luetkens H, Khasanov R, Zimmermann M V, Yin J X, Wang Z, Chang J, Monserrat B, Gawryluk D, von Rohr F O, Kim S W, and Guguchia Z 2026 *Nat. Commun.* **17** 1121