On the superconductivity of the Li$_x$RhB$_y$ compositions

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Abstract

We observed superconductivity ($T_c \simeq 2−3$ K) in Li$_x$RhB$_y$ intermetallics wherein $x$ and $y$ vary over a wide compositional range. The crystal structure consists of a cubic unit-cell ($a \simeq 12.1$ Å) with a centrosymmetric space group, $Pn\bar{3}m$. A weak but positive pressure-induced increase of $T_c$ was observed. The correlations between the composition and each of the following were observed: the unit-cell dimensions, $T_c$, Sommerfeld coefficient $\gamma$, Debye temperature $\theta_D$, and critical fields $H_{c1}$ and $H_{c2}$. The thermal evolution of the electronic specific heat within the superconducting phase followed a quadratic-in-$T$ behavior. In addition, a paramagnetic Meissner effect (PME) was manifested during a low-field-cooled magnetization cycle. The manifestation of the quadratic-in-$T$ behavior as well as the PME feature will be discussed.

Keywords: intermetallic superconductors, lithium rhodium boride, pressure-dependent magnetization, paramagnetic Meissner effect

1. Introduction

Recently, we reported [1] the observation of superconductivity ($T_c \simeq 2$ to 3 K at ambient pressure) in a novel ternary Li$_x$RhB$_y$ phase. This phase was found to be stable over a wide range of Li and B content (namely $0.6 < x < 2$, $1 < y < 2$) while maintaining: (i) the same cubic unit-cell ($\sim 12.1$ Å, see figure 1), (ii) the same normal-state properties (e.g., the Sommerfeld constant $\gamma \sim 3$ mJ molK$^{-2}$ and Debye temperatures $\theta_D \sim 250$ K), and (iii) the same superconducting properties (e.g., $T_c \sim 3$ K, $H_{c1}(0) \sim 65$ Oe, $H_{c2}(0) \sim 14$ kOe). However, it was difficult to reconcile its thermodynamic properties with the reported symmetry of its crystal structure (see below) [1]. In this work, we resolve this difficulty by carrying out extensive structural, magnetic, magnetoresistivity, and thermal characterizations.
Our earlier structural analysis showed that based on the observed extinction rule (absence of \((00l)\) lines for \(l = \text{odd}\)), the possible proposed space groups were either \(P2_13\) or \(P4_32\). Given that these groups are characterized by a noncentrosymmetric feature and that the Rh atom has a high \(Z\)-number, it was concluded that the effects of anisotropic spin-orbit coupling (ASOC) should be manifested [2–5]. In general, the presence of such ASOC would lead to characteristic features such as: (i) a removal of the spin degeneracy, which, in turn, would lead to an enhanced normal-state Pauli paramagnetism, and (ii) an admixture of even-parity spin-singlet and odd-parity spin-triplet pairing states, which may cause a manifestation of nodes in the structure of the quasiparticle gap function. As a result of such ASOC influences, many thermodynamical properties should exhibit a characteristic thermal evolution. [2–5] (e.g., (i) the superconducting specific heat, \(C_S(T < T_c)\), should manifest a power-in-\(T\) behavior [2–5], (ii) the susceptibility of the superconducting state should be increased, and (iii) the upper critical field, \(H_{c2}(0)\), should exceed the Pauli paramagnetic limit \(H_p \cong 3 k_B T_c/\mu_B\sqrt{2}\) [6]).

Our earlier thermodynamical characterization on \(\text{Li}_x\text{RhB}_y\) indicated that while \(C_S(T < T_c)\) does exhibit a quadratic-in-\(T\) behavior, which is expected for line nodes, neither the susceptibility nor the evolution of the \(H_{c2}(T)\) curve confirm such an unconventional character. One of the objectives of the present work is to address this contradiction.

The present structural analysis, carried out on more than four dozen samples, indicates that the space group of these \(\text{Li}_x\text{RhB}_y\) compositions is the centrosymmetric \(Pn\bar{3}m\) rather than the previously reported noncentrosymmetric \(P2_13\) or \(P4_32\) [1]. This removes the contradiction between the structural and thermodynamic properties. On the other hand, the above-mentioned contradiction among the thermodynamic properties will be discussed in term of conventional, rather than nonconventional, influences. Finally, we followed the evolution of the superconducting properties with the variations in the hydrostatic pressure, structural properties, and

![Figure 1](image-url). Representative room-temperature x-ray diffractograms of \(\text{Li}_x\text{RhB}_y\), emphasizing the stability of the almost-single-phase cubic structure in spite of the wide variation in \(x\) and \(y\). Symbols: measured intensities. Short bars: the Bragg positions. Lower thin line: the difference curve. Solid line: Rietveld calculated pattern using \(Pn\bar{3}m\) (see text). The extremely weak impurity lines (the more intense ones are marked with short vertical arrow) are found to be related to nonsuperconducting \(\text{Li}_2\text{RhB}_2\) (more evident at \(x > 1\) and \(y \approx 1.5\)), nonsuperconducting \(\text{RhB}\) (more evident at \(x < 1\) and \(y \approx 1\)), and an unknown tetragonal phase (more evident at \(0.4 < x < 1.5\) and \(y \approx 1\)).

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material properties of these compositions, including the unit-cell volume, stoichiometry, sample purity, defects concentrations, etc.

2. Experimental setup

To the best of our knowledge, the stabilization of a ternary Li-Rh-B compound has been reported only for the following non-superconducting cases: (i) the hexagonal Li$_3$RhB$_2$ \((a = 8.45\ \text{Å} \text{ and } c = 4.287\ \text{Å})\) \[7\], and (ii) the orthorhombic Li$_2$Rh$_3$B$_2$ \((a = 5.7712\ \text{Å}, b = 9.4377\ \text{Å}, c = 2.8301\ \text{Å})\) \[8\]. Badica et al \[9\] attempted a synthesis of Li$_2$Rh$_3$B, but the product was found to be multiphasic, consisting mainly of binary boride and elemental Li and B.

Polycrystalline samples of various Li$_x$Rh$_y$B$_z$ compositions \((0.4 \leq x \leq 3 \text{ and } 1 \leq y \leq 2)\) were synthesized by a standard solid-state reaction of pure Li lump (99.9%), Rh powder (99.95%), and crystalline B powder (99%). First, Rh and B were mixed and pressed into pellets, and then, together with the Li lump, the pellets were placed in a Ta foil or a BN crucible and sealed in a stainless container under an argon atmosphere. The container was heated up to 700–900 °C for 20 h, followed by furnace cooling. After cooling, these products were annealed at the same temperature range.

The weight loss during the heating process was found to be less than 0.2%. This result had been confirmed by the elemental analysis, which was conducted using the inductively coupled plasma (ICP) method on representative samples. Before the analysis, we first used aqua regia and then K$_2$S$_2$O$_7$ to completely dissolve the Rh. The analytical determinations of each element (given in table 1) are close to the nominal compositions, which is a reassuring result considering that both Li and B are light elements and the former is volatile.

Structural analysis of all investigated polycrystalline samples was carried out on a monochromatic Cu $K\alpha$ diffractometer equipped with a Si detector, as pictured in figure 1. Magnetization curves were measured on a superconducting quantum interference device (SQUID) magnetometer. Bulk samples were cut into a cylindrical shape \((\phi 0.45 \times 0.50\ \text{cm})\) and sealed in a gelatin capsule, all of which was handled in an inert-gas glove box. Pressure-dependent magnetization curves were measured with a low-temperature hydrostatic micro-pressure cell (up to 1 GPa) operated within a SQUID environment. Daphne oil was used as a pressure-transmitting fluid while Sn was used as a manometer. Magnetoresistance curves were measured on parallelepiped samples of typical \(0.11 \times 0.12 \times 0.45\ \text{cm}^3\) dimensions. We used a conventional dc, four-point method (1 mA) in a home-made probe, which was operated within the environment of the above-mentioned magnetometer. Zero-field specific heat measurements were carried out on a semi-adiabatic calorimeter operating within the range of \(0.5 < T < 23\ \text{K}\) with a precision better than 4%.

During all experiments, we took care to avoid air/moisture exposure since such exposure was found to cause a dimming of metallic luster and, furthermore, a reduction in both $T_c$ and the superconducting volume fraction. As such, samples were usually covered with apiezon N grease and guarded in an inert atmosphere. For remeasurement, the grease was wiped off.

Some samples show double superconducting transitions in their magnetization, resistivity, or specific heat. Given that the $T_c$ of these transitions is \(~2\) to 3 K and that the measured diffractograms do not exhibit any of the known superconducting contaminant phases (see the
Table 1. Some parameters of Li$_x$RhB$_y$ compositions where $x$ and $y$ represent the measured content of Li and B relative to Rh, as determined by the ICP method. $a$ is the parameter of the cubic cell (standard deviation reflects the variation associated with differing sample batches); the onset $T_c$ as determined from magnetization, resistivity, or specific heat curves; $H_{c1}(0)$ K as determined from the magnetization curves; $H_{c2}(0)$ as determined from the magnetoresistivity curves; $\beta$, $\gamma$, and $\delta_L$ coefficients as determined from the specific heat measurements. $\theta_D$ is estimated to be within the range of 240–260 K. The coherence length, $\xi(0)$, and the penetration depth, $\lambda(0)$, were calculated from the following Ginzburg–Landau expressions: $H_{c2}(t) = \Phi_0/(2 \pi \xi(0)^2(1-t))$ and $H_{c1}(0) = \Phi_0/[(4 \pi \lambda(0)^2 \ln(\lambda(0)/\xi(0)))$, where $\Phi_0$ is the flux quantum and $t = T/T_c$. The calculated $H_{c2}(0)$ K was determined from the quadratic and Werthamer–Helfand–Hohenberg (WHH) expressions (see text).

| Nominal | Measured | $T_c$ | $a$ | $H_{c1}(0)$ | $H_{c2}^{\text{quad}}(0)$ | $\xi(0)$ | $\lambda(0)$ | $\alpha$ | $H_{c2}^{\text{WHH}}(0)$ | $\gamma$ | $\beta$ | $\delta_L$ |
|---------|----------|------|----|------------|----------------|------|-------------|------|----------------|------|------|------|
| Li$_{0.8}$RhB$_{1.5}$ | 0.87 | 1.47 | 2.4 | 12.079(1) | 83.5 | 13.7 | 15.5 | 15.7 | 0.29 | 9.6 | 3.3 | 0.46 | 0.024 |
| Li$_{1.0}$RhB$_{1.5}$ | 0.95 | 1.48 | 2.6 | 12.086(7) | 77 | 8.1 | 20.2 | 20.6 | 0.17 | 5.6 | 2.8 | 0.37 | 0.024 |
| Li$_{1.2}$RhB$_{1.5}$ | 1.02 | 1.52 | 2.6 | 12.089(9) | 65.6 | 14.2 | 14.4 | 14.5 | 0.3 | 9.8 | 2.4 | 0.40 | 0.024 |
caption of figure 1 and the text below), then the manifestation of such double transitions is most likely related to the granular character of these samples.

3. Results

3.1. Structural Analysis

Extensive structural and elemental analyses were carried out on more than four dozen \( \text{Li}_{x}\text{RhB}_{y} \) compositions, covering the range of \( 0.6 \leq x \leq 1.4 \) and \( 0.5 \leq y \leq 2 \) while keeping Rh stoichiometry fixed. As one can see in the representative figures 1 and 2 (upper panel), and table 1, and in the electron diffraction patterns of [1], the almost-single phase is stable over the range \( 0.8 \leq x \leq 1.5 \) and \( 1 \leq y \leq 2 \), but its concentration is strongly decreased when \( x \) or \( y \) is far from this range. All related Bragg lines can be indexed if one adopts a large-sized cubic unit-cell (see, e.g., figure 1).

The wide variation in Li and B content, as well as their low atomic scattering factors, make it extremely difficult to correctly ascertain their stoichiometry or to calculate the involved density. Nonetheless, applying of extinction rules to resolution-improved diffractograms suggested that the space group is the centrosymmetric \( Pn\overline{3}m \). Furthermore, using the Le–Bail method and Patterson maps, the atomic positions of the heavier Rh atoms are conclusively identified (for more details, see [10]); Rh occupies the Wyckoff positions \( 4i \) and \( 12e \). Furthermore, it seems that B occupies the position \( 8c \), leading to the formation of both some distorted and undistorted octahedrons, which is a feature also common in other Rh-B compositions. Note that although these structural considerations lead only to partial determination and that further elucidation requires the identification of the exact stoichiometry and positions of the Li and B atoms (a task which would be effectively served by using, for example, neutron diffraction analysis). Nonetheless the calculated Rietveld patterns (figure 1) compare favorably with experiments and, as such, confirm the correct identification of the space.
group, all Rh positions, and one position of B [10]. More encouraging evidence comes from the fact that on taking Li$_x$RhB$_y$ with, say, $x \approx xy$, 1 or 1.5, one calculates a density of 6.8 to 7.3 $\text{g cm}^{-3}$, which is comparable to 7.35 $\text{g cm}^{-3}$ of Li$_2$Rh$_3$B$_2$ [8]. Unfortunately, due to the strong porous character of these materials, we were unable to measure their density by conventional methods [10].

The correlation of the unit-cell $a$-parameter with the Li/B content is shown in the upper contour plot of figure 2. Evidently, on fixing Li (B) content and varying B (Li) concentration, the evolution of the $a$-parameter does not reflect any Vegard’s law. In fact, a variation in the small-sized Li and B in Li$_x$RhB$_y$ over the whole range of $0.4 \leq x \leq 1$ and $1 \leq y \leq 2$ modifies the unit-cell volume by only 1.1%, emphasizing the crucial role of the Rh sublattice.

3.2. Magnetization

Zero-field-cooled (ZFC) magnetization of Li$_x$RhB$_y$ (figure 3) exhibits a strong shielding signal. Field-cooled (FC) magnetization, on the other hand, indicates a paramagnetic Meissner effect (PME), which is a negative drop immediately below $T_c$ followed by a surge of a net (positive) paramagnetism, indicative of a spontaneous magnetic moment, well below $T_c$. The diffractograms of these three representative samples are shown in figures 1(c), (d), and (e). Each is practically a single-phase cubic structure. This, together with the observed thermal evolution of this effect (as well as that of the isothermal field-dependent magnetization for $H > H_{c2}$), indicates that it is not related to an extrinsic contaminating paramagnetic center. Generally, PME appears in granular superconductors, wherein inverse Josephson couplings (the so-called $\pi$ contacts) are formed at the boundaries of multiply-connected superconducting grains [12--14]. Such boundaries may arise either due to extrinsic factors such as disorder or
impurity, or intrinsic factors such as boundaries that connect differently oriented crystallites of superconductors with unconventional pairings [14]. Since the space group is centrosymmetric, no strong ASOC effects are expected and the presence of PME is most likely related to extrinsic factors or extreme porosity [10]. Indeed, the strength of the PME varies within different batches of the same sample.

The obtained $T_c$ is shown as a function of the Li/B content in figure 2; $T_c$ reaches a maximum within an approximate triangle-shaped region having $(x, y)$ vertices as $(0.8, 1.5)$, $(1.0, 1.8)$, and $(1.2, 1.6)$. Accordingly, the three Li$_x$RhB$_{1.5}$ $(x = 0.8, 1.0, 1.2)$ samples were extensively studied since they are faithful representatives of the whole series. Their $a$-parameters stabilize around 12.08–12.10 Å (see figure 2). Furthermore, a variation in their Li/B content influences $T_c$, most likely through an induced variation in $N(E_F)$, Debye temperature $\theta_D$, or pairing interaction $U$ (e.g., as in the Bardeen–Cooper–Schrieffer relation $T_c = 0.85\theta_D \exp\left(-1/UN(E_F)\right)$). Since most of these parameters can be varied through pressure, we also investigated the influence of applied pressure ($p$) on the superconductivity of these Li$_x$RhB$_y$ compositions. The pressure-dependent magnetization (figure 4) indicates that both the superconducting fraction and $T_c$ are weakly enhanced. In particular, for pressures up to 1 GPa and to a second order in $p$, $T_c \approx T_{c0} + d_1p + d_2p^2$ (in GPa), where $T_{c0} = 2.50, 2.50, 2.38$ K; $d_1 = \frac{dT_c}{dp} = 0.09, 0.24, 0.13$ K/GPa; $d_2 = \frac{d^2T_c}{2dp^2} = 0.01, -0.09, -0.05$ for Li$_x$RhB$_{1.5}$ $(x = 0.8, 1.0, 1.2)$, respectively. Evidently the overall pressure influence is almost linear and rather weak. Relatively speaking, Li$_{1.0}$RhB$_{1.5}$ (mid-panel of figure 4) exhibits a more pronounced $P$-induced variation.

Figure 5 shows the isothermal magnetization curves of Li$_x$RhB$_{1.5}$: typical type-II curves with no strong positive normal-state paramagnetic susceptibility (absence of strong polarization). This latter result is in agreement with the same features exhibited in figures 3 and 4: all confirm the absence of ASOC effects. Based on these isothermal curves of figure 5,
we determined the thermal evolution of $H_{c1}$ (for $H_{c2}$, see below) which, as one can see in figures 6(a)–(c), follows reasonably well the relation $H_{c1} = H_{c1}(0)[1-t^2]$, wherein $H_{c1}(0)$ and $T_c$ are as given in table 1.

3.3. Magnetoresistivity

The thermal evolution of the resistivity of Li$_x$RhB$_{1.5}$ shown in figure 7, $\rho(T_c < T \leq 300 \text{ K})$, figures 6(a)–(c), indicates a metallic normal state. For most samples, $\rho(T = 300 \text{ K}) \leq 0.48 \text{ m}\Omega\cdot\text{cm}$, while the residual resistivity in the immediate range above $T_c$ is $\leq 0.12 \text{ m}\Omega\cdot\text{cm}$. That $\rho(300 \text{ K})/\rho(4.2 \text{ K}) \sim 4$ suggests additional scattering processes such as a random atomic distribution, or interstitial or substitutional defects related to Li/B nonstoichiometry. Figure 7 also indicates a superconducting state with a transition which, due to percolation, is much

Figure 5. Isotherm $M(H)$ curves of Li$_x$RhB$_{1.5}$: (a) $x = 1.2$, (b) $x = 1.0$, (c) $x = 0.8$. For clarity, the ordinate scale of the lower panel was expanded by a factor of two.

Figure 6. (a), (b), and (c): Measured $H_{c1}(T)$ (symbols) of Li$_x$RhB$_{1.5}$ was fitted (solid lines) to the relation $H_{c1} = H_{c1}(0)(1-t^2)$, where $t = T/T_c$. (d), (e), and (f): measured $H_{c2}(T)$ of Li$_x$RhB$_{1.5}$ (symbol) was analyzed using (i) the quadratic formula $H_{c2}(t) = H_{c2}[1-t^2/(1+t^2)]$ (solid line) and (ii) the WHH expression (dashed lines).
sharper and narrower than the transitions observed in the magnetizations or specific heats. Because of these advantageous features, $H_{c2}(T)$, figure 6, was determined from the midpoint of the transition occurring in each of $\rho(T, H)$ curve of figure 7, rather than from the event occurring in each $M(H)$ isotherm of figure 5.

3.4. Specific Heat

The specific heats of the Li$_x$RhB$_y$ samples evolve, within $T_c < T < 5$ K, as $\gamma T + \beta T^3$ [1]; $\gamma$ and $\beta$ are given in table 1. Just like $T_c$ and the lattice parameter, there is a weak Li-dependence of both $\gamma$ and $\beta$; $\gamma$, in particular, decreases slightly as the Li content is increased.

The electronic contribution, $C_{el}(T)$, obtained after subtracting the Debye part ($\beta T^3$), is shown in figure 8. For a conventional BCS-type gapped superconductor, the electronic contribution below $T_c$ is dominated by an exponential-in-$T$ behavior. Figure 8 does not show any exponential evolution, and as such, the gap is either not fully developed or blurred by some anomalous behavior. The origin behind such a behavior may be revealed if one obtains an analytical expression of the thermal evolution of $C_{el}(T < T_c)$. But first, let us evaluate whether $C_{el}$ is due solely to the superconducting phase contribution. In that regard, the inset of figure 8 indicates that the typical superconducting shielding fraction of these samples is 80% of the signal obtained from a similar-sized Sn sample [1]. It was assumed that the residual normal state gives rise to a $0.2\gamma T$ contribution. Figure 8 indicates that the relation $C_{el}(T < T_c) = 0.2\gamma T + 0.8\delta L(T/T_c)^2$ describes the electronic contribution reasonably well. The obtained values of $\delta L$ are similar for all compositions, namely 24 mJ molK$^{-1}$; this suggests a correlation between $\delta L$ and the electronic contribution of the Rh sublattice, since such a contribution does not vary across the studied samples. Though the arguments given in [1] attributed such a quadratic-in-$T$ behavior to line nodes, our present understanding, based on the above-mentioned crystallographic and thermodynamics arguments, is that this power relation may be related to distribution effects arising from, say, variation in the Li/B content. (For evidence regarding $H_{c2}(0)$, see below).
4. Discussion and conclusions

Based on the correlation between $T_c$ and the volume ($V = a^3$) shown in figure 2, one expects:

$$\frac{\partial T_c}{\partial p} = \frac{1}{V} \frac{\partial V}{\partial p} \frac{\partial T_c}{\partial V} = \beta \cdot V \cdot \frac{\partial T_c}{\partial V},$$

where $\beta$ is the compressibility of the solid. Although there is no information on $\beta (T, p), V (T, p)$, or the lattice anisotropy, it is possible to correlate the observed weak pressure dependence of $T_c$ with the general features of the upper panel of figure 2. These particular samples are situated within a Li/B region where the overall variation of $T_c$ with $V$ (thus with pressure) is weak; even weaker dependence is observed for regions with an excess or deficiency of Li content. From these features (see also table 1), it can be concluded that a variation in pressure or Li content (B is fixed) would not bring about any strong variation in $T_c$, $N(E_F)$, $\theta_D$, or $U$.

The thermal evolution of each $H_{c2}(T)$ curve, shown in figures 6(d)–(f), was analyzed in terms of (i) the quadratic Ginzburg–Landau relation, $H_{c2}(T) = H_{c2}[(1 - \frac{T}{T_c})/(1 + \frac{T}{T_c})]$, and (ii) the WHH expression [15, 16], which is usually parameterized in terms of $\alpha$ (a measure of the Pauli spin effect) and $\lambda_{so}$ (a measure of the spin–orbit scattering). While $\lambda_{so}$ is a fit parameter, $\alpha$ is taken to be determined experimentally, based on the relation [15, 16] $\alpha = 5.33 \times 10^{-5}(\partial H_{c2}/\partial T)|_{T_c}$, giving 0.17, 0.29, 0.3 for $x = 0.8$, 1.0 and 1.2, respectively. As expected, both descriptions of $H_{c2}(T)$ satisfactorily reproduce the measured curves within the range $T \to T_c$. In fact, both descriptions are reasonable within the available temperature range since this range is still very close to $T_c$ ($t = T/T_c \to 1$). In general, the WHH description is more appropriate for the range $T \to 0$. Accordingly, we used the relation $H_{c2}(0) = -0.693T_c(\partial H_{c2}/\partial T)|_{T_c}$ to evaluate $H_{c2}(0)$, giving 5.6, 9.6, and 9.8 kOe for $x = 0.8$, 1.0, and 1.2, respectively. Such $H_{c2}(0)$ values are surprisingly low. In fact they are one order of magnitude lower than the paramagnetic limit $H_p$. 

Figure 8. The electronic specific heat contribution of (a) Li$_{1.2}$RB$_{1.5}$, (b) Li$_{1.0}$RB$_{1.5}$, and (c) Li$_{0.8}$RB$_{1.5}$ obtained after subtracting the calculated Debye contribution, $C_{el} = C_{el} - \beta T^3$. The dashed lines are least-square fits to $C_{el} = \gamma T$, while the solid thick lines represent the calculation $0.2(\gamma T) + 0.80\alpha_L(T/T_c)^2$ (see text). The specific heat jump at $T_c$ is not sharp but the structure, just below $T_c$, is evident as in the magnetization curve (see inset). Inset: As a representative, the diamagnetism of Li$_{0.8}$RB$_{1.5}$ is 80% of that of a Sn sample with the same shape and size; this is attributed to a presence of normal-state regions (see text).
\[ \cong 3k_B T_c / \mu_B \sqrt{2} \simeq 80 \text{kOe}. \] As such, this constitutes additional evidence, which, together with the above-mentioned evidences confirm the absence of ASOC effects. Indeed, in spite of the higher Z value of Rh, the WHH analysis of \( H_{c2} (T) \) (figure 6) indicates no significant role for the \( \lambda_{so} \) parameter. Accordingly, \( H_{c2} (T) \) in these \( \text{Li}_x \text{RhB}_y \) compositions is taken to be determined by the standard orbital-driven depairing process.

In summary, \( \text{Li}_x \text{RhB}_y \) compositions form a new class of Li-based superconductors. The variation in Li/B ratio is accompanied by a weak change in the unit-cell length in both the normal-state properties (e.g., \( \gamma \), \( \beta \)) and the superconducting properties (e.g., \( H_{c1}(0) \), \( H_{c2}(0) \), and \( T_c \)). Many of the studied parameters are interrelated. For example, the \( a \)-parameter and \( T_c \) are correlated and, furthermore, this same correlation is evident in the positive pressure dependence of \( T_c \). As these materials are centrosymmetric superconductors, the observations of PME during the FC \( M(T) \) cycle and the quadratic-in-\( T \) superconducting specific heat are attributed to conventional (rather than nonconventional) features such as inhomogeneous distribution of defects or Li/B atoms. Indeed, the thermal evolution of \( H_{c2} (T) \) can be described by a conventional WHH expression. Finally, based on the observed correlation between composition, \( V \), and the \( T_c \) of \( \text{Li}_x \text{RhB}_y \), it would be very interesting to carry out a systematic study on the Li-\( M \)-X series (\( M = \) transition metal, \( X = \) B, As, Si, Ge).

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