Fractional quantization of the residual resistivity and the normal state resistivity at the superconducting transition

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Abstract

The author provides a literature study showing that the residual resistivity and the normal state resistivity at the superconducting transition might be fractionally quantized. Surprisingly, fractional quantized resistivity is observed in the absence of strong magnetic fields. The presented phenomenological classification of 280 single crystals is based on six universal resistivity quanta that are only dependent on natural constants.

Keywords: universality, fractional quantization, residual resistivity, superconductivity, natural constants.

The purpose of this work is to present data found in the open access literature on residual resistivities ρ_0 and normal state resistivities at the superconducting transition $\rho(T_c)$ of high-quality single crystals. These absolute values are rarely mentioned explicitly in the literature because they are strongly sample dependent and not reproducible, seeming to have no connection to fundamental physics. To obtain values from literature data, they must, in most cases, be calculated using model functions (e.g., Fermi liquid) or extracted from figures using graphic design software with a ruler tool for measuring distances.

In conventional thinking, the residual resistivity is caused by the scattering of conduction electrons at lattice defects and atomic impurities that destroy the crystalline periodicity. However, considering the number of defects in a crystal as the only origin of ρ_0 leads to a problem with highly conducting oxide metals (e.g., $PdCoO_2$). In these compounds, the number of defects per lattice site is, according to the resistivity at low temperatures, extremely small and conflicts with chemistry. Thus, the residual resistivity cannot solely be induced by impurity or defect scattering.

Resistivity is an emergent feature of the metallic state that ceases to exist when a complex aggregate of atoms (e.g., a crystal) falls apart. The author speculates that resistivity has universal properties and is independent of microscopic material-specific details; that is, nature forgets which components make up a single-phase crystal. The property changes in quanta and assumes very specific universal values that are not determined by classical electrodynamics because, in addition to the electrical charge q_e, the Planck constant h also plays a role.

Let $(h/q_e^2)\,\ell$ with $\ell \equiv \alpha\,\lambda_{e\_bar}, \alpha\,\lambda_e, \lambda_{e\_bar}, \lambda_e, \alpha^{-1}\,\lambda_{e\_bar}, \alpha^{-1}\,\lambda_e$ be the allowed resistivity quanta. The ratio h/q_e^2 is the von Klitzing constant with the numerical value ≈ 25 812.807 45 Ω. The parameter α is the Sommerfeld fine structure constant defined by the number constant $\alpha \equiv 2^{-6}\pi^{-2/3}$ [1a]. The quantities λ_e and λ_{e_bar} are the Compton wavelength and the reduced Compton wavelength $\lambda_e/(2\pi)$ of the electron, respectively. Like the von Klitzing constant, both are tabulated by CODATA. When everything is combined, ≈ 0.0073, ≈ 0.0456, ≈ 0.997, ≈ 6.263, ≈ 136.8, and ≈ 859.8 μΩcm result for the resistivity quanta. The resistivity $\rho(T\rightarrow 0)$ and $\rho(T_c)$ shall be fractionalized according to $\boldsymbol{\rho = \upsilon\,\rho_{quantum}}$, with υ being an element of the 55 relatively prime factors $\upsilon \equiv p/q$ that can be formed from $p, q \in \{1, 2, \ldots\ldots, 9\}$ [1b].

The measurement of resistivities requires careful investigation and must be carried out along each crystallographic axis, that is, the samples must be aligned very precisely via diffraction before each measurement. Because of inhomogeneities that can be caused by chemical doping, pressure, or magnetic fields, measurements of stoichiometric compounds at ambient pressure and at zero external magnetic field were selected. Even then, it is challenging to obtain accurate absolute values because the geometric factor that transforms the measured resistance R into the resistivity ρ = R (area/length) requires samples with well-defined geometries. Unfortunately, information about the size of a single crystal, its homogeneity, or the error of the geometric factor is usually missing in the literature.

The collected results of a large number of studies with corresponding interpretations are compiled in Table 1. Care was taken to ensure that the resistivity at $T\rightarrow 0$ or $T=T_c$ is flat, that is, has a low temperature dependence, tends to saturate, and leads to a resistivity plateau, so that the error in determining the resistivity is minimized. It is up to the reader to judge and verify whether the extracted, experimental values in Table 1 are coincidences or whether the simple ansatz $\rho = \upsilon\,\rho_{quantum}$ could be a unifying, comprehensive model underlying the data. Undoubtedly, more accurate measurements of precisely aligned, single-phase crystals with well-defined geometries are required.

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Table 1: Fractional Quantization of the residual resistivity

single crystal	item	info [a]	RRR [b]	$T_c^{\rho}{}_{onset}$ [c] [K]	resistivity [μΩcm]			fraction	varia	ref
					measured [d]	ansatz [e]	quantum [f]	υ		
$Ag_5Pb_2O_6$		Text		ρ_{ab}	1.5	1.50	0.997	3/2		[2]
$Ag_5Pb_2O_6$		Fig. 1		0.044	4.63(4)	4.70	6.263	3/4	ρ^c	[3]
$Ag_5Pb_2O_6$	#1	FL		$\rho_0{}^c$	4.7	4.70	6.263	3/4		[4]
Al_6Re		Fig. 2	375	ρ_0	0.0394(4)	0.0391	0.0456	6/7		[5]
Al_6Re		Text		ρ_0	0.04	0.040	**0.0456**	7/8		[6]
As	#A1	PL		ρ_0	0.038	0.0380	0.0456	5/6		[7]
	#A2	PL		ρ_0	0.0093	0.00934	0.0073	9/7		
	#A3	PL		ρ_0	0.0014	0.00145	0.0073	1/5		
$AuSn_4$		Text		2.4	0.62	0.623	0.997	5/8		[8]
$AuSn_4$		Text		2.4	0.75	0.748	0.997	3/4		[9]
$AuSn_4$		Fig. 3a		2.52	2.48(3)	2.492	**0.997**	5/2		[10]
$AuSn_4$		Text		2.60	10.8	11.0	6.263	7/4		[11]
$AuTe_2$		Text		ρ_0	0.78	0.775	**0.997**	7/9		[12]
		Fig. 2c			0.774(5)					
		Fig. 2c			0.397(4)	0.399	0.997	2/5	0.95GPa	
$AuTe_2Se_{4/3}$	#1	FL		2.85	37.4	37.6	6.263	6		[13]
	#2	Fig. 4c		2.85	27.9(2)	28.2	6.263	9/2		
$Ba_5In_4Bi_5$		Fig. 3a		4.62	16.5(2)	16.7	6.263	8/3		[14]
		Fig. S8a		4.55	14.0(2)	14.1	6.263	9/4		
		Fig. S7a		4.4	9.0(1)	8.97	0.997	9		
$Ba_6Nb_{11}S_{28}$		Fig. 1f		1.6	62.0(5)	60.8	136.8	4/9		[15]
$BaAl_4$	#A	Text		ρ_0	0.090	0.091	0.0456	2		[16]
$BaBi_3$		FL		5.95	12.50	12.53	6.263	2		[17]
$BaCu_2As_2$		Fig. 4c		ρ_0	1.750(3)	1.744	0.997	7/4		[18]
$BaGa_2$		Text		$\rho_0{}^{xx}$	0.440	0.443	0.997	4/9		[19]
$BaIr_2P_2$		Fig. 3c		ρ(3K;750G)	8.81(6)	8.77	6.263	7/5		[20]
$BaNi_2As_2$		Fig. 4a		ρ(1.5K;0.1T)	16.7(1)	16.70	6.263	8/3		[21]
$BaNi_2P_2$		Fig. 1a		2.6	5.05(4)	5.01	6.263	4/5		[22]
$BaNiS_2$		PL		$\rho_0{}^{ab}$	5.5	5.48	6.263	7/8		[23]
$BaPd_2As_2$		Fig. 2b		3.85	5.20(6)	5.22	6.263	5/6		[24]
$BaPt_2As_2$		Fig. 6a		1.75	106.2(7)	106.4	136.8	7/9		[25]
$BaRh_2P_2$		Fig. 3d		1.08	2.63(3)	2.66	0.997	8/3		[20]
		Fig. 3d		ρ(1.5K;1T)	1.27(1)	1.282	0.997	9/7		
$BaSn_3$		Fig. 1b		4.4	24.5(3)	25.1	6.263	4		[26]
$BaTi_2Sb_2O$		Fig. 1d		2.5	11.0(1)	11.0	6.263	7/4		[27]
$Bi_2Ir_2O_7$		Fig. 3a		ρ_0	342.10(3)	342.10	136.8	5/2)		[28]
Bi_2PdPt		Fig. 4		4.1	3.12(3)	3.13	6.263	1/2		[29]
$Ca_{11}Bi_{10}$		Fig. 2b		2.3	10.8(2)	11.0	6.263	7/4		[30]
$Ca_3Ir_4Sn_{13}$		Fig. 2a		7.5	85(1)	85.5	136.8	5/8		[31]
CaAgAs		Text		$\rho_0{}^{xx}$	25	25.1	6.263	4		[32]
$CaAl_4$		Fig. 2a	57	$\rho_0{}^{xx}$	0.788(5)	0.783	6.263	1/8		[33]
$CaBi_2$		Text		ρ_0	0.219	0.222	0.997	2/9		[34]
CaCdGe		Text		$\rho_0{}^{xx}$	9	9.0	0.997	9		[32]

Table 1: Fractional Quantization of the residual resistivity

single crystal	item	info [a]	RRR [b]	$T_c^{\rho}{}_{onset}$ [c] [K]	resistivity [μΩcm]			fraction	varia	ref
					measured [d]	ansatz [e]	quantum [f]	υ		
CaCdSn		Text		ρ_0	0.6	0.60	0.997	3/5		[35]
$CaCu_3Ru_4O_{12}$	#1	FL		ρ_0	14	14.1	6.263	9/4		[36]
	#2	FL		ρ_0	117	117.3	136.8	6/7		
$CaIrSi_3$		Fig. 3b		3.45	68(1)	68.4	136.8	1/2		[37]
$CaPd_2Ge_2$		BG		2.0	12.03(3)	12.5	6.263	2		[38]
$CaPd_2P_2$		BG		1.0	23.5	22.8	136.8	1/6		[39]
CaPtAs		FL		1.58	10.50	10.44	6.263	5/3		[40]
		Fig. 2a		1.38	7.53(6)	7.52	6.263	6/5	plateau	
CaPtAs		Fig. 5a		1.40	117.5(7)	117.3	136.8	6/7		[41]
		Fig. 4a		1.30	143(1)	143	859.8	1/6		
$CaSb_2$		Text		2.0	0.77	0.775	**0.997**	7/9		[42]
$CaSn_3$		Text		4.2	0.5	0.498	0.997	1/2		[43]
$CaSn_3$		FL		4.2	1.348	1.329	0.997	4/3		[44]
$Cd_2Re_2O_7$	#B	Text		2.15	11	11.0	6.263	7/4		[45]
$Cd_2Re_2O_7$		FL		1.46	14.63	14.61	6.263	7/3		[46]
$Cd_2Re_2O_7$		FL		1.72	17.07	17.11	136.8	1/8		[47]
$Cd_2Re_2O_7$	#2A	Fig. 4		1.13	15.7(1)	15.7	6.263	5/2		[48]
	#1A	Fig. 4		2.20	15.7(1)	15.7	6.263	5/2		
	#1F	Fig. 4		2.17	11.3(1)	11.3	6.263	9/5		
	#1G	Fig. 2		1.06	11.1(1)	11.0	6.263	7/4		
Cd_3As_2		Text		ρ_0^{xx}	28.2	28.2	6.263	9/2		[49]
Ce_2PdGe_3		Fig. 7b		ρ_0	175.0(1)	175.9	136.8	9/7		[50]
$CeRu_2$		Fig. 1d		5.1	37.8(5)	37.6	6.263	6		[51]
Co_2MnGa		Text		ρ_0^{xx}	56	56.4	6.263	9		[52]
Co_2MnSi		Text		ρ_0	7	6.98	**0.997**	7		[53]
$Co_3Sn_2S_2$		Fig. 2b	128	ρ_0	4.20(4)	4.18	6.263	2/3		[54]
$CoSe_2$		Text		ρ_0	2.1	2.09	6.263	1/3		[55]
CoSi		Fig. 1d	14	ρ_0^{xx}	4.97(3)	4.98	**0.997**	5		[56]
$CoTe_2$		Text		ρ_0	113.8	114	136.8	5/6		[57]
$CrAuTe_4$		Text		ρ_0	5.566	5.567	6.263	8/9		[58]
$CsNi_2Se_2$		FL		2.7	5.38	5.368	6.263	6/7		[59]
CsV_3Sb_5		Fig. 1a		4.0	0.248(2)	0.249	0.997	1/4		[60]
CsV_3Sb_5	pristine	Text		4.2	0.4	0.40	0.997	2/5		[61]
CsV_3Sb_5		Fig. 2e		3.6	0.555(4)	0.554	0.997	5/9		[62]
CsV_3Sb_5		Fig. S1b		3.85	1.19(1)	1.196	0.997	6/5		[63]
CsV_3Sb_5		Fig. 1b		4.0	1.76(1)	1.744	0.997	7/4		[64]
CsV_3Sb_5	#B	Fig. 1c		3.8	3.00(2)	2.99	0.997	3		[65]
CsV_3Sb_5		Fig. 1a		4.0	4.03(3)	3.99	0.997	4		[66]
CsV_3Sb_5		Text		4.2	4.75	4.70	6.263	3/4		[67]
		Fig. 2b			4.74(4)					

Table 1: Fractional Quantization of the residual resistivity

single crystal	item	info [a]	RRR [b]	$T_c^{\rho}{}_{onset}$ [c] [K]	resistivity [μΩcm]			fraction	varia	ref
					measured [d]	ansatz [e]	quantum [f]	υ		
CsV_3Sb_5	#1	Fig. 2a		3.6	3.62(4)	3.58	6.263	4/7	0GPa	
	#1			5.2	3.72(4)	3.76	6.263	3/5	0.37GPa	
	#1			8.0	2.99(4)	2.99	0.997	3	1.86GPa	
	#1			8.0	4.20(5)	4.18	6.263	2/3	1.52GPa	[68]
	#1			8.0	4.46(5)	4.47	6.263	5/7	1.46GPa	
	#4	Fig. 2b		3.6	1.41(2)	1.40	0.997	7/5	5.2GPa	
	#4			4.6	1.32(2)	1.33	0.997	4/3	3.8GPa	
Cu_3Sn		BG		$\rho_0{}^b$	0.17(1)	0.17	0.997	1/6		[69]
				$\rho_0{}^a$	0.34(1)	0.33	0.997	1/3		
CuS	#1	Fig. 2b		1.8	0.578(7)	0.570	0.997	4/7		[70]
CuTe		Text		ρ_0	1.19	1.196	0.997	6/5		[71]
Fe_2P		Fig. 5a	760	ρ_0	0.224(2)	0.222	0.997	2/9		[72]
HfP_2		Fig. 1e		ρ_0	5.06(6)	5.01	**6.263**	4/5		[73]
HfRuP		Fig. 1e		9.0	2540(20)	2579	859.8	3		[74]
HoPdBi		Fig. 1a		0.82	642(6)	645	859.8	3/4		[75]
InPd		Text		ρ_0	16.6	16.7	6.263	8/3		[76]
$IrSb_3$	#73.1	PL		ρ_0	3.57	3.58	6.263	4/7		[77]
$K_2Cr_3As_3$		Fig. 2a	60	6.2	16.8(1)	16.7	6.263	8/3		[78]
$K_2Cr_3As_3$		Fig. 2	50	6.2	19.3(1)	19.5	136.8	1/7		[79]
KCo_2As_2	#1	Fig. 3a	160	$\rho_0{}^{xx}$	0.229(1)	0.228	0.0456	5		[80]
KCr_3As_3	#B	Fig. 2b		5.2	161(1)	160	136.8	7/6		[78]
KV_3Sb_5		Fig. 2e		1.4	0.290(3)	0.285	0.997	2/7		[81]
KV_3Sb_5		Fig. 1c	45	ρ_0	1.61(1)	1.595	0.997	8/5		[82]
La_2Ni_2In		Text		0.94	15.7(1)	15.7	6.263	5/2		[83]
$La_2Pt_3Ge_5$		Fig. 5		8.2	10.8(2)	11.0	6.263	7/4		[84]
$La_2Rh_{3+\delta}Sb_4$	#1	FL		0.9	43.6	43.8	6.263	7		[85]
		Fig. 4a			43.6(4)					
$La_3Co_4Sn_{13}$		Fig. 4a		3.0	43.7(3)	43.8	6.263	7		[86]
$La_3Pt_3Bi_4$		Fig. 3c		1.15	36.6(4)	37.6	6.263	6		[87]
La_7Ir_3		Text		2.5	52.5(5)	51.3	136.8	3/8		[88]
LaAlSi		Fig. 1c		$\rho_0{}^{xx}$	5.96(4)	5.98	0.997	6		[89]
LaBi		Fig. 1a	665	ρ_0	0.182(2)	0.182	0.0456	4		[90]
$LaCo_2P_2$		Fig. 4a	69	ρ_0	1.195(8)	1.196	0.997	6/5		[91]
$LaCoGe_3$		Fig. 3	150	ρ_0	0.270(2)	0.274	0.0456	6		[92]
$LaCu_2Si_2$		Text		ρ_0	0.87	0.872	0.997	7/8		[93]
$LaCuSb_2$		Fig. 2b		1.1	1.93(2)	1.99	0.997	2		[94]
		Fig. 3a		ρ(1.6K;0T)	1.20	1.20	0.997	6/5		
$LaNiGa_2$		FL		2.15	5.20	5.22	6.263	5/6		[95]
$LaOs_4Sb_{12}$		Text		ρ_0	2.8	2.78	6.263	4/9		[96]
$LaPt_2Si_2$		Fig. 1b		1.22	55.0	54.7	136.8	2/5		[97]
$LaPt_2Si_2$		Fig. 1b		2.15	109.6(8)	109.5	136.8	4/5		
		Fig. 3a		2.36	19.7(1)	19.5	136.8	1/7	2.0GPa	[98]
		Fig. 3a		2.36	15.2(1)	15.2	136.8	1/9	2.4GPa	

Table 1: Fractional Quantization of the residual resistivity

single crystal item	info [a]	RRR [b]	$T_c^{\rho}{}_{onset}$ [c] [K]	resistivity [μΩcm]			fraction	varia	ref
				measured [d]	ansatz [e]	quantum [f]	υ		
$LaPt_2Si_2$	Fig. 2a		1.8	182(1)	182	136.8	4/3		[99]
$LaRh_2As_2$	BG		0.35	10	10.0	6.263	8/5		[100]
	Fig. 3a		0.27	9.0(1)	9.0	0.997	9		
$LaRhGe_3$	Fig. 7a		ρ_0	0.77(1)	0.775	0.997	7/9		[101]
LaRhSn	Fig. 1		2.2	24.5(3)	25.1	6.263	4		[102]
LaRhSn	Fig. 5		2.2	50.0(5)	50.1	6.263	8		[103]
	Fig. 4		2.2	106(1)	106.4	136.8	7/9		
$LaRu_2P_2$	Fig. 4		4.4	2.08(1)	2.09	6.263	1/3		[104]
$LaRu_2Zn_{20}$	Fig. 1		0.3	27.4(2)	27.4	136.8	1/5		[105]
$LaRu_4As_{12}$	Fig. 1		10.4	1.330(8)	1.329	0.997	4/3		[106]
LaSb #1	PL		ρ_0	0.080	0.080	0.0456	7/4		[107]
LaSb #2			ρ_0	0.330	0.332	0.997	1/3		
$LaTe_3$	Fig. 3		ρ_0^{ac}	0.433(8)	0.427	0.997	3/7		[108]
			ρ_0^{b}	98(1)	97.7	136.8	5/7		
LiFeP	FL		5.3	2.26	2.24	0.997	9/4		[109]
Li_xTaS_2	Text		4.2	611(2)	614	859.8	5/7		[110]
$Lu_2Fe_3Si_5$	Fig. 5		5.76	4.06(6)	3.99	0.997	4		[111]
	Fig. 5		5.56	15.0(1)	15.2	136.8	1/9		
$Lu_2Fe_3Si_5$	Text		6.2	7.0	7.05	6.263	9/8	ρ_0^{c}	[112]
				22	21.9	6.263	7/2	ρ_0^{ab}	
$Lu_3Os_4Ge_{13}$	Fig. 1a		3.30	382(7)	382	859.8	4/9		[113]
$Lu_5Rh_6Sn_{18}$	Fig. 3a		4.4	183(2)	182	136.8	4/3		[114]
$LuNiSi_3$	Text		1.63	1.8	1.79	**0.997**	9/5		[115]
	Fig. 7b			1.80(1)					
LuPdBi	Fig. 2c		1.9	344(2)	344	**859.8**	2/5		[116]
LuPdBi	Fig. 3a		1.70	405(5)	411	136.8	3		[117]
	3a inset			200(3)	205	136.8	3/2)		
LuPtBi	Fig. 3		1.05	74.5(4)	76.0	136.8	5/9		[118]
$MgCNi_3$	Fig. 3		6.65	31.5(3)	31.3	6.263	5		[119]
Mn_2P	Fig. 2b	840	ρ_0	0.0798(4)	0.0798	0.0456	7/4		[72]
Mo_3Sb_7	gap		2.38	91.6	91.2	136.8	2/3		[120]
Mo_3Sb_7	Fig. 1b		2.35	90.7(8)	91.2	136.8	2/3		[121]
$MoGe_2$	PL		ρ_0	1.4	1.40	0.997	7/5		[122]
$Na_2Cr_3As_3$	Text	12	8.8	108.3	107.5	859.8	1/8		[123]
$Na_6Co_3Se_6O_3$	Fig. 2c		6.5	136.6(8)	136.8	136.8	1		[124]
NaAlSi	Text		7.2	157	156.4	136.8	8/7	ρ^{a}	[125]
$NaSn_2As_2$	Fig. 3a		1.65	60.4(4)	60.8	136.8	4/9		[126]
$NaSn_2As_2$	Text		1.18	122	121.6	136.8	8/9		[127]
$NaSn_2As_2$	Fig. 2b		1.38	171(2)	171	**136.8**	5/4		[128]
NbC	Fig. 2c		12.7	27.4(2)	27.4	136.8	1/5		[129]
$NbGe_2$	Fig. 3a		2.1	0.080	0.080	0.0456	7/4		[130]
$NbGe_2$	Fig. 1		2.06	0.094(1)	0.091	0.0456	2		[131]

Table 1: Fractional Quantization of the residual resistivity

single crystal item	info [a]	RRR [b]	$T_c^{\rho}{}_{onset}$ [c] [K]	resistivity [μΩcm]			fraction	varia	ref
				measured [d]	ansatz [e]	quantum [f]	υ		
$NbGe_2$	BG		$\rho_0^{out\ of\ plane}$	0.050	0.0508	0.0073	7		[132]
	BG		$\rho_0^{in\ plane}$	0.165	0.166	0.997	1/6		
$NbIrTe_4$	Fig. 2a		ρ(0.35K)	15.7(1)	15.7	6.263	5/2		[133]
$NbIrTe_4$ #2	Fig. 1e	19	ρ_0^{xx}	31.3(3)	31.3	6.263	5		[134]
	Fig. 2e		2.95	820(4)	821	136.8	6	65.5GPa	
NbP	Text		ρ_0	0.63	0.623	0.997	5/8		[135]
NbSeTe	Fig. 3a		3.16	207.2(5)	205	136.8	3/2		[136]
$NbSi_2$	Text		ρ_0	0.074	0.0730	0.0456	8/5		[137]
$NbTe_2$	Fig. 1d		0.72	12.6(2)	12.5	6.263	2		[138]
$NbTe_4$	Text		ρ_0	9.4	9.39	6.263	3/2		[139]
$NdAuAl_4Ge_2$	Fig. 4b		ρ_0	4.72(4)	4.70	6.263	3/4		[140]
$Ni_3In_2S_2$	Text		ρ_0^{xx}	0.108	0.1064	0.0456	7/3		[141]
$Ni_3In_2Se_2$	Fig. 2a	30	ρ_0^{xx}	1.01(1)	1.00	0.997	1		[142]
$NiBi_3$	Fig. 3		4.1	5.13(5)	5.22	6.263	5/6		[143]
$NiBi_3$	Fig. 1c		4.3	7.76(5)	7.83	6.263	5/4		[144]
$NiBi_3$	Fig. 2b		4.16	4.16(5)	4.18	6.263	2/3		[145]
	BG			4.5(2)	4.49	**0.997**	9/2		
	Fig. 4a			4.50(4)					
$NiBi_3$	Fig. 2a		4.3	58.6(6)	58.6	136.8	3/7		[146]
NiMnSb	Fig. 6a	1.65	ρ_0	31.22	31.31	6.263	5		[53]
$NiTe_2$	Fig. 2a	374	ρ_0^{xx}	0.116(1)	0.114	0.0456	5/2		[147]
$NiTe_2$	Fig. 2c		ρ_0	1.000	0.997	0.997	1		[148]
OsB_2	Text		2.20	1.55	1.566	6.263	1/4		[149]
$Pb_{1/3}TaS_2$	Fig. 2e		3.45	1.99(1)	1.994	0.997	2		[150]
Pb_2Pd	Fig. 4		3.2	2.10(4)	2.09	6.263	1/3		[151]
$PbTaS_2$	FL		2.6	0.319	0.319	0.0456	7		[152]
$PbTaSe_2$	Text		4.0	0.14	0.142	0.997	1/7		[153]
$PbTaSe_2$	Text		3.9	0.14	0.142	0.997	1/7		[154]
$PbTaSe_2$	Fig. 6b		4.05	0.271(2)	0.274	0.0456	6		[155]
$PbTaSe_2$	BG		4.0	0.28	0.285	0.997	2/7		[156]
$PbTaSe_2$	Fig. S4b		4.1	0.332(5)	0.332	0.997	1/3		[157]
$PbTaSe_2$	Fig. 1a		4.1	0.360(4)	0.365	0.0456	8		[158]
$PbTaSe_2$	Fig. 2a		4.1	0.374(3)	0.374	0.997	3/8		[159]
$PbTe_2$	Fig. 2		1.82	0.495(6)	0.498	0.997	1/2		[160]
$PdCoO_2$	Fig. 3		ρ_0^{ab}	0.00741(1)	0.00726	0.0073	1		[161]
			ρ_0^{c}	8.08(5)	8.05	6.263	9/7		
$PdCrO_2$	Text		ρ_0^{ab}	0.045	0.0456	0.0456	1		[162]
			ρ_0^{c}	16.5	16.7	6.263	8/3		
PdGa	Fig. 2a	37	ρ_0^{xx}	0.595(4)	0.598	0.997	3/5		[163]
PdGa	Fig.1c	20	ρ_0	0.713(5)	0.712	0.997	5/7		[164]
$PdSn_4$ #1	FL		ρ_0	0.105	0.106	0.0456	7/3		[165]
PdTe	Fig. 2a		4.6	3.13(2)	3.13	6.263	1/2		[166]
$PdTe_2$	BG		ρ_0	8.02	8.05	6.263	9/7		[167]

Table 1: Fractional Quantization of the residual resistivity

single crystal	item	info [a]	RRR [b]	$T_c^{\rho}{}_{onset}$ [c] [K]	resistivity [μΩcm]			fraction	varia	ref
					measured [d]	ansatz [e]	quantum [f]	υ		
$Pr_2Ir_2O_7$		Fig. 4a		ρ_0	364.5(3)	364.9	136.8	8/3		[168]
$Pr_2Pt_3Ge_5$		Fig. 5		7.9	28.3(2)	28.2	6.263	9/2		[84]
PrAlGe		Fig. 2a		ρ_0	30.6	30.4	136.8	2/9		[169]
PrAlSi		Fig. 5		ρ_0	19.0(2)	18.8	6.263	3		[170]
PrCoIn5		Text		ρ_0	0.034	0.0342	0.0456	3/4		[171]
$PrFe_4P_{12}$		Text		ρ_0	0.57	0.570	0.997	4/7		[172]
$PrOs_4Sb_{12}$		Text		ρ_0	8	7.97	**0.997**	8		[96]
$PrTi_2Al_{20}$		Text		0.183	0.380	0.374	0.997	3/8		[173]
Pt_2HgSe_3	#D1	Text		ρ_0^{xx}	17.1	17.1	136.8	1/8		[174]
	#D2			ρ_0^{xx}	10.4	10.4	6.263	5/3		
	#D3			ρ_0^{xx}	6.3	6.3	6.263	1		
Pt_3Te_4		Text		ρ_0^{xx}	0.45	0.443	0.997	4/9		[175]
PtAl		Fig. 2a		ρ_0	5.06(7)	5.01	**6.263**	4/5		[176]
$PtBi_2$		FL		ρ_0	0.018	0.0182	**0.0456**	2/5		[177]
$PtCoO_2$		Fig. 2a		ρ_0^{ab}	0.04070(5)	0.04055	0.0456	8/9		[178]
$PtPb_4$		Text		3.0	0.709	0.712	**0.997**	5/7		[179]
		Fig. 2a	113		0.711(6)					
$PtPb_4$		FL		2.8	0.753	0.748	0.997	3/4		[180]
$PtPb_4$		Fig. 2a		2.77	2.78(3)	2.78	6.263	4/9		[181]
$PtSn_4$		Text		ρ_0	0.013	0.0130	**0.0456**	2/7		[182]
$PtSn_4$		Text		ρ_0	0.045	0.0456	0.0456	1		[183]
$PtSn_4$		Text		ρ_0	0.045	0.0456	0.0456	1		[184]
$PtSn_4$	#1	Text		ρ_0	0.041	0.041	0.0456	8/9		[185]
	#2				0.053	0.053	0.0456	7/6		
	#3				0.038	0.038	0.0456	5/6		
$PtSn_4$		Text	812	ρ_0^a	0.315	0.319	0.0456	7		[186]
$PtSn_4$		Text		ρ_0	0.5	0.50	0.997	1/2		[187]
$Rb_2Cr_3As_3$		Fig. 2b		5.0	3.57(4)	3.58	6.263	4/7		[189]
$Rb_2Cr_3As_3$	#A	Fig. 5a		4.8	7.52(4)	7.52	6.263	6/5		[188]
$RbCr_3As_3$		Fig. 2b		8.0	12.5(1)	12.5	6.263	2		[189]
Re_6Zr		Fig. 1a		6.84	208(4)	205	136.8	3/2		[190]
Re_6Zr		Text		6.9	300	308	136.8	9/4		[191]
$Rh_{17}S_{15}$	pristine	Fig. 2		5.31	16.5(1)	16.7	6.263	8/3		[192]
RhSn		Fig. 2a	24	ρ_0^{xx}	3.16(2)	3.13	6.263	1/2		[193]
$Sc_5Rh_6Sn_{18}$		Fig. S3		5.05	229(4)	228	136.8	5/3		[194]
$SmAuAl_4Ge_2$		Text		ρ_0	1.5	1.50	0.997	3/2		[195]
$SmCd_{11}$		Text		ρ_0	0.32	0.319	0.0456	7		[196]
		Fig. 2a		4.7	2.99(2)	2.99	0.997	3	T_{N1}	
$Sn_{0.4}Sb_{0.6}$		Fig. 8		4.0	82.4(2)	82.1	136.8	3/5		[197]
Sn_4Au		Fig. 1c		2.3	1.50(2)	1.50	0.997	3/2		[198]
Sn_4P_3		Text		1.9	0.14	0.142	0.997	1/7		[199]
SnAs		Text		4.2	1.28	1.282	0.997	9/7		[200]
$SnTaS_2$		Fig. 1c		3.05	0.063(1)	0.0639	0.0456	7/5		[201]

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single crystal	item	info [a]	RRR [b]	$T_c^{\rho}{}_{onset}$ [c] [K]	resistivity [μΩcm]			fraction	varia	ref
					measured [d]	ansatz [e]	quantum [f]	υ		
$SnTaS_2$		Fig. 2a		2.9	0.099(1)	0.103	0.0456	9/4		[202]
SrAgSb		Fig. 7		ρ_0^{xx}	27.6(2)	27.4	136.8	1/5		[203]
SrAuBi	#3	Fig. 4a		2.5	68.3(5)	68.4	136.8	1/2		[204]
SrAuSb		Fig. 7		ρ_0^{xx}	22.9(2)	22.8	136.8	1/6		[203]
$SrBi_3$		Fig. 8b		5.75	0.166(2)	0.166	0.997	1/6		[205]
$SrIn_2As_2$		Fig. 1c		ρ_0	490(3)	491	859.8	4/7		[206]
$SrNi_2P_2$		Fig. 1b		1.55	1.55(2)	1.566	6.263	1/4		[207]
$SrPd_2Ge_2$		Fig. 3		2.96	68.2(6)	68.4	136.8	1/2		[208]
$SrPd_2P_2$		BG		0.7	67.8	68.4	136.8	1/2		[39]
$SrPt_{10}P_4$		Fig. 3		1.5	9.3(2)	9.4	6.263	3/2		[209]
$SrPt_2As_2$		Fig. 1a		5.50	78.2(3)	78.2	136.8	4/7		[210]
$SrPt_3P$		FL		8.6	15.2	15.2	136.8	1/9		[211]
$SrSn_2As_2$		Fig. 1d		ρ_0	43.7(3)	43.8	6.263	7		[212]
$SrVO_3$		Text		ρ_0	0.41	0.411	0.0456	9	190 u.c.	[213]
$SrVO_3$		Text		ρ_0	172.4	172.0	859.8	1/5		[214]
$Ta_3Pd_3Te_{14}$	#1	Fig. 2c		1.05	5.17(3)	5.22	6.263	5/6	ρ^b	[215]
$TaCo_2Te_2$		Text		ρ_0	2.244	2.243	0.997	9/4		[216]
$TaCo_2Te_2$		Fig. 4a	17	ρ_0^{xx}	11.4(1)	11.3	6.263	9/5		[217]
$TaPdTe_5$		Text	59	ρ_0^a	0.559	0.554	0.997	5/9		[218]
$TaSb_2$		Text		ρ_0^{xx}	0.75	0.748	0.997	3/4		[219]
$TaSe_3$		PL		ρ_0^b	14.5	14.6	6.263	7/3		[220]
TaSeS		Fig. 3a		4.2	156(1)	156.4	136.8	8/7		[221]
$TaSi_2$		Text		ρ_0	0.014	0.0145	0.0073	2		[137]
TaSSe		Fig. 4a		4.0	645(7)	645	859.8	3/4		[222]
$Th_2Cu_4As_5$		Fig. 2a		4.2	1745(15)	1720	859.8	2		[223]
$ThIn_3$		Text		ρ_0	0.32	0.319	0.0456	7		[224]
Ti_2Sn_3		Fig. 2a	130	ρ_0	0.322(3)	0.319	0.0456	7		[225]
$Tl_{0.6}Bi_2Te_3$		Text		2.42	200	205	136.8	3/2		[226]
U_6Co		FL		2.75	54.1	54.7	136.8	2/5		[227]
UBe_{13}		Fig. 2 Text		1.8 10	231(2) 228	228	136.8	5/3	 flat max	[228]
UNi_2Al_3		Text		0.91	3.6	3.58	6.263	4/7		[229]
W_2As_3		Text		ρ_0^{xx}	1.04	1.044	6.263	1/6		[230]
W_2As_3	#1 #2 #3	Fig. 3a Fig. 3a Fig. 3a	291 311 372	ρ_0^{xx} ρ_0^{xx} ρ_0^{xx}	0.571(4) 0.450(4) 0.570(4)	0.570 0.443 0.570	0.997 0.997 0.997	4/7 4/9 4/7		[231]
WP	#3	Fig. 2		0.85	1.12(1)	1.121	0.997	9/8		[232]
WP_2	#C2 #C5	Fig. 1e Text	24850	ρ_0	0.00165(2) 0.012	0.00161 0.0121	0.0073 0.0073	2/9 5/3	 sup note	[233]
WSi_2		Text		ρ_0	0.103	0.103	0.0456	9/4		[234]
WTe_2		Fig. 1a, ext	2000	ρ_0	0.169(2)	0.166	0.997	1/6		[235]
WTe_2		Text		ρ_0	0.185	0.182	0.0456	4		[236]
WTe_2		Text		ρ_0^a	0.275	0.274	0.0456	6	Table I	[237]

Table 1: Fractional Quantization of the residual resistivity

single crystal	item	info [a]	RRR [b]	$T_c^{\rho}{}_{onset}$ [c] [K]	resistivity [μΩcm]			fraction	varia	ref
					measured [d]	ansatz [e]	quantum [f]	υ		
WTe_2		Fig. 1c	58	ρ_0	10.03(7)	10.02	6.263	8/5		[238]
WTe_2		Fig. 1b		ρ_0^{xx}	11.25(15)	11.27	6.263	9/5		[239]
$Y_3Ru_4Ge_{13}$		Fig. 3		3.0	92.3(8)	91.2	136.8	2/3		[240]
$Y_3Ru_4Ge_{13}$		Fig. 1a		3.21	846(8)	860	859.8	1		[113]
Y_4RuGe_8		Fig. 6a		1.35	46.0(4)	45.6	136.8	1/3		[241]
$Y_5Rh_6Sn_{18}$		Fig. 2		3	368(3)	368	859.8	3/7		[242]
$Y_7Ru_4InGe_{12}$		Fig. 2c		5.78	26.5(2)	27.4	136.8	1/5		[243]
$Yb_2Ni_{12}P_7$		FL		ρ_0	21.96	21.92	6.263	7/2		[244]
$Yb_2Pt_6Al_{15}$		FL		ρ_0	1.65	1.661	0.997	5/3	I ⊥ c	[245]
YB_6		Fig. 1a		7.5	10.0(1)	10.0	6.263	8/5		[246]
$YbAl_2$		Fig. 3	45	ρ_0	0.503(4)	0.498	0.997	1/2		[247]
$YbFe_2Zn_{20}$		FL		ρ_0	8.4	8.35	6.263	4/3		[248]
YbV_3Sb_4		Text		ρ_0	11.1	11.0	6.263	7/4		[249]
YCd_6		Text		ρ_0	1.2	1.20	0.997	6/5		[250]
$YCoGa_5$		Fig. 3b		ρ_0^{ab}	0.142(1)	0.142	0.997	1/7		[251]
YCr_6Ge_6		Fig. 3		$\rho_0^{\perp}$	4.5	4.49	0.997	9/2		[252]
YNi_2B_2C		Fig. 1		15.9	3.21(2)	3.13	6.263	1/2		[253]
YNi_2B_2C		PL		16.1	3.75	3.76	6.263	3/5		[254]
$YNiSi_3$		Text		1.36	0.33	0.332	0.997	1/3		[115]
YPtBi	#1	Fig. 3		0.77	159(1)	159.6	136.8	7/6		[255]
	#3	Fig. 1			143(1)	143	859.8	1/6		
YPtBi		Fig. 1		1.05	689(4)	688	859.8	4/5	ρ^{xx}	[256]
YRh_6Ge_4	#1	Fig. 2b		ρ_0^{xx}	39.7(3)	39.1	136.8	2/7		[257]
	#3	Fig, 2a		ρ_0^{xx}	19.6(3)	19.5	136.8	1/7		
YSi		Text	17	ρ_0	1.55	1.57	6.263	1/4	I ∥ (001)	[258]
			22		4.86	4.87	6.263	7/9	I ∥ (100)	
ZrB_{12}		Fig. 3		6.03	1.79(1)	1.79	**6.263**	2/7		[259]
ZrRuAs		Fig. 1d		8.3	164(1)	164	136.8	6/5		[74]
ZrSiS		Text		ρ_0	0.052	0.0521	0.0456	8/7		[260]
ZrSiS		Fig. 1b	50	ρ_0	0.290(3)	0.285	0.997	2/7		[261]
ZrSiS		Text		ρ_0^{xx}	0.18	0.182	0.0456	4	I ∥ (100)	[262]
					0.38	0.374	0.997	3/8	I ∥ (110)	
$ZrZn_2$		PL		ρ_0	0.80	0.797	0.997	4/5		[263]
α-BiPd		Fig. 1a		4.10	0.360(2)	0.365	0.0456	8		[264]
α-$PdBi_2$		Text		1.7	7	6.98	**0.997**	7		[265]
α-$PdBi_2$		Fig. 2b		1.60	12.2(2)	12.5	6.263	2		[266]
α-$PdBi_2$		Text		1.7	18	18.8	6.263	3		[267]
		Fig. 2		2.5	18.4(2)					
α-RhSi		Text		ρ_0^{xx}	0.78	0.783	**6.263**	1/8		[268]
β-Al_3Mg_2		Text		0.93	33.3	34.2	136.8	1/4		[269]
β-Bi_2Pd		Fig. 2c		5.4	5.0	5.01	6.263	4/5		[270]
β-Bi_2Pd		Text		5.0	22	21.9	6.263	7/2		[271]
β-Bi_2Pd		Fig. 1b		5.05	21.7(1)	21.9	6.263	7/2		[272]

Table 1: Fractional Quantization of the residual resistivity

single crystal item	info [a]	RRR [b]	$T_c^{\rho}{}_{onset}$ [c] [K]	resistivity [μΩcm]			fraction	varia	ref
				measured [d]	ansatz [e]	quantum [f]	υ		
β-Bi_2Pd	Text		4.86	23	22.8	136.8	1/6		[273]
β-Bi_2Pd	Fig. 1b		5.3	32.0(4)	31.3	6.263	5		[274]
β-$IrSn_4$	Fig. 3a		1.03	3.13(4)	3.13	6.263	1/2		[275]
β-$PtBi_2$	Text		ρ_0	0.065	0.064	**0.0456**	7/5		[273]
β-$YbAlB_4$ #A	Text Fig. 4a		0.082	0.4 0.40(1)	0.40	0.997	2/5		[276]
β-$YbAlB_4$	Fig. 1a		0.097	0.422(1)	0.427	0.997	3/7		[277]
β-$YbAlB_4$	Fig. S5a		0.090	0.423(4)	0.427	0.997	3/7		[278]
β-$YbAlB_4$	Fig. 1		0.083	0.490(6)	0.498	0.997	1/2		[279]
β-$YbAlB_4$ #1 #2	Fig. 1a		0.074 0.083	1.34(1) 0.49(1)	1.33 0.50	0.997 0.997	4/3 1/2		[280]

Notes:

a) Information on how the measured residual resistivity ρ_0 or $\rho(T_c)$ was determined:
Text the value is explicitly mentioned in the text.
Figure the value was extracted from the figure using a ruler.
FL the value was calculated using the parameters of the **Fermi Liquid** fitting function mentioned in the text.
PL the value was calculated using the parameters of the **Power Law** fitting function mentioned in the text.
BG the value was calculated using the parameters of the **Bloch Grüneisen** fitting function in the text.
Gap the value was calculated using the parameters of the **Gap** fitting function mentioned in the text.

b) If the residual resistivity ratio (RRR) is listed, RRR was used to calculate ρ_0 or $\rho(T_c)$ from $\rho_{Room\ Temperature}$.

c) For a superconductor $T_c^{\rho}{}_{onset}$ in Kelvin is listed; otherwise, ρ_0 is indicated for differentiating.

d) Unless otherwise stated, the measured resistivity refers to ambient pressure and a zero magnetic field. An estimate of the error associated with the extraction from the figure due to incorrect placement of the ruler is given in round brackets. This information is missing for a calculated value and for a value explicitly mentioned in the article.

e) The ansatz is:
$\rho = \upsilon\, \rho_{quantum} \equiv \upsilon\, (h/q_e^2)\, \ell$
with $\ell \equiv \alpha\, \lambda_{e\_bar}$, $\alpha\, \lambda_e$, λ_{e_bar} , λ_e , $\alpha^{-1}\, \lambda_{e\_bar}$, $\alpha^{-1}\, \lambda_e$

f) A bold value means the interpretation is ambiguous because more than one quantum is consistent with the experiment. For example, 0.997 (5/2) gives ≈ 2.49 μΩcm and 6.263 (2/5) gives ≈ 2.51 μΩcm, which in most cases cannot be distinguished experimentally.