Instructions for data analysis : SS08 remote

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SS08r

Introduction

After reading through the manuscript for the experiment SS08 — *superconductivity*[1], follow the data collection and analysis in order, starting with subsection 4.1.

Manuscript subsection 4.1

The process for filling the cryostat, measuring the resistance of the first tin wire probe (”probe A”), and inserting it into the cryostat is described in the video clip: SS08 video part 1.

The resistance is now measured carefully by cooling down the sample in several short steps by pumping on the liquid helium to ensure that it is evaporating at temperatures controlled by the pumping rate. This is shown in the clip: SS08 video part 2

You should now download the directory ”SS08 Data for Remote” from Canvas[2] which has all of the data and information that you need to perform the analysis, organised into sections corresponding to the main manuscript.

Throughout the rest of the experiment, you will be using the vapour pressure to measure the liquid helium temperature. This is based on accurate values given in the paper by Durieux and Rusby [1], where the pressure is measured in units of *pascals*, where 1 mbar = 100 Pa. In order to make this easier you can use the lookup table given in Appendix A, or alternatively the empirical fitting function:

$$T = 1.24177 + 0.23793x + 0.36207x^2 - 0.33188x^3 + 0.20738x^4 - 0.05294x^5 + 0.00552x^6$$

where $x = log(P/\mathrm{mbar})$. Use whichever approach you find most convenient.

You can now complete the analysis for subsubsection 4.1.2 with the data ”Resistivity Data Remote”, which can also be downloaded from Canvas. The magnetic-field-dependent resistivity dataset for subsubsection 4.1.3 is taken as described in the clip: SS08 video part 3. Analyse as much of this dataset as you can.

Manuscript subsection 4.2

The dataset for section 4.2 is taken using probe B, uses the integrated voltage from the measurement coil to determine the magnetic flux inside the sample and is in the subsection 4.2 subdirectory. It has already been corrected to ensure that there is no DC offset, as referred to in the script. The procedure for taking and understanding this dataset is shown in the clip: SS08 video part 4. Analyse as much of this dataset as you have time for.

[1] `www-teaching.physics.ox.ac.uk/practical_course/scripts/srv/local/rscripts/trunk/CM/SS08/SS08.pdf`

[2] Data files for SS08 can be accessed at `https://canvas.ox.ac.uk/courses/68360/files/folder/CMP/SS08`

Manuscript subsection 4.3

Subsection 4.3 ("Persistent currents in lead") is shown in: SS08 video part 5. This has two additional datasets to analyse on top of what is in the normal script, where the Pb sample in probe C has also been through the sequence:

- measured at 4.2 K for a complete hysteresis loop, then warmed to approximately 10 K by moving it up into the He gas;
- cooled to 1.34 K and the hysteresis loop re-measured;
- the helium cryostat has been re-pressurised with warm helium gas from above and the hysteresis loop re-measured again.

These are given in the three files in subsection 4.3. In addition to explaining why the graphs have the shapes that they do, and calculating the current flowing in the Pb cylinder, you should also be able to make an estimate of the values of B_0 and T_c for Pb, and the value of the He temperature after the cryostat is re-pressurised.

Bibliography

[1] M. Durieux and R. L. Rusby, *Metrologia*, **19**, 67 (1983). doi: 10.1088/0026-1394/19/2/004

A Appendix: vapour pressure lookup table

This table is based on the polynomials given in [1].

p (mbar)	T (K)	p (mbar)	T (K)	p (mbar)	T (K)	p (mbar)	T (K)	p (mbar)	T (K)
1	1.226	1.1	1.240	1.2	1.254	1.3	1.266	1.4	1.278
1.5	1.288	1.6	1.299	1.7	1.309	1.8	1.318	1.9	1.327
2	1.336	3	1.408	4	1.463	5	1.509	6	1.547
7	1.582	8	1.612	9	1.640	-	-	-	-
10	1.666	11	1.690	12	1.712	13	1.733	14	1.753
15	1.771	16	1.789	17	1.806	18	1.823	19	1.838
20	1.854	21	1.868	22	1.882	23	1.896	24	1.909
25	1.922	26	1.935	27	1.947	28	1.959	29	1.970
30	1.981	31	1.992	32	2.003	33	2.014	34	2.024
35	2.034	36	2.044	37	2.054	38	2.064	39	2.073
40	2.083	41	2.092	42	2.101	43	2.110	44	2.119
45	2.127	46	2.136	47	2.144	48	2.152	49	2.161
50	2.169	51	2.177	52	2.185	53	2.193	54	2.200
55	2.208	56	2.216	57	2.223	58	2.230	59	2.238
60	2.245	61	2.252	62	2.259	63	2.266	64	2.273
65	2.280	66	2.287	67	2.293	68	2.300	69	2.306
70	2.313	71	2.319	72	2.326	73	2.332	74	2.338
75	2.344	76	2.351	77	2.357	78	2.363	79	2.369
80	2.375	81	2.380	82	2.386	83	2.392	84	2.398
85	2.403	86	2.409	87	2.415	88	2.420	89	2.426
90	2.431	91	2.437	92	2.442	93	2.447	94	2.453
95	2.458	96	2.463	97	2.468	98	2.473	99	2.478
100	2.483	101	2.488	102	2.493	103	2.498	104	2.503
105	2.508	106	2.513	107	2.518	108	2.523	109	2.528
110	2.532	111	2.537	112	2.542	113	2.546	114	2.551
115	2.556	116	2.560	117	2.565	118	2.569	119	2.574
120	2.578	121	2.583	122	2.587	123	2.591	124	2.596
125	2.600	126	2.604	127	2.609	128	2.613	129	2.617
130	2.621	131	2.626	132	2.630	133	2.634	134	2.638
135	2.642	136	2.646	137	2.650	138	2.655	139	2.659
140	2.663	141	2.667	142	2.671	143	2.674	144	2.678
145	2.682	146	2.686	147	2.690	148	2.694	149	2.698
150	2.702	151	2.706	152	2.709	153	2.713	154	2.717
155	2.721	156	2.724	157	2.728	158	2.732	159	2.735
160	2.739	161	2.743	162	2.746	163	2.750	164	2.754
165	2.757	166	2.761	167	2.764	168	2.768	169	2.771
170	2.775	171	2.778	172	2.782	173	2.785	174	2.789
175	2.792	176	2.796	177	2.799	178	2.803	179	2.806
180	2.809	181	2.813	182	2.816	183	2.819	184	2.823
185	2.826	186	2.829	187	2.833	188	2.836	189	2.839
190	2.842	191	2.846	192	2.849	193	2.852	194	2.855
195	2.859	196	2.862	197	2.865	198	2.868	199	2.871
200	2.874	201	2.878	202	2.881	203	2.884	204	2.887
205	2.890	206	2.893	207	2.896	208	2.899	209	2.902
210	2.905	211	2.908	212	2.911	213	2.914	214	2.917
215	2.920	216	2.923	217	2.926	218	2.929	219	2.932
220	2.935	221	2.938	222	2.941	223	2.944	224	2.947

(continued on following page)

p (mbar)	T (K)	p (mbar)	T (K)	p (mbar)	T (K)	p (mbar)	T (K)	p (mbar)	T (K)
225	2.950	226	2.953	227	2.956	228	2.959	229	2.961
230	2.964	231	2.967	232	2.970	233	2.973	234	2.976
235	2.978	236	2.981	237	2.984	238	2.987	239	2.990
240	2.992	241	2.995	242	2.998	243	3.001	244	3.003
245	3.006	246	3.009	247	3.012	248	3.014	249	3.017
250	3.020	251	3.022	252	3.025	253	3.028	254	3.031
255	3.033	256	3.036	257	3.039	258	3.041	259	3.044
260	3.046	261	3.049	262	3.052	263	3.054	264	3.057
265	3.059	266	3.062	267	3.065	268	3.067	269	3.070
270	3.072	271	3.075	272	3.078	273	3.080	274	3.083
275	3.085	276	3.088	277	3.090	278	3.093	279	3.095
280	3.098	281	3.100	282	3.103	283	3.105	284	3.108
285	3.110	286	3.113	287	3.115	288	3.118	289	3.120
290	3.122	291	3.125	292	3.127	293	3.130	294	3.132
295	3.135	296	3.137	297	3.139	298	3.142	299	3.144
300	3.147	305	3.158	310	3.170	315	3.182	320	3.193
325	3.205	330	3.216	335	3.227	340	3.238	345	3.249
350	3.260	355	3.270	360	3.281	365	3.291	370	3.302
375	3.312	380	3.322	385	3.332	390	3.342	395	3.352
400	3.362	405	3.372	410	3.382	415	3.391	420	3.401
425	3.410	430	3.420	435	3.429	440	3.438	445	3.447
450	3.457	455	3.466	460	3.475	465	3.483	470	3.492
475	3.501	480	3.510	485	3.518	490	3.527	495	3.535
500	3.544	505	3.552	510	3.561	515	3.569	520	3.577
525	3.586	530	3.594	535	3.602	540	3.610	545	3.618
550	3.626	555	3.634	560	3.641	565	3.649	570	3.657
575	3.665	580	3.672	585	3.680	590	3.688	595	3.695
600	3.703	605	3.710	610	3.717	615	3.725	620	3.732
625	3.739	630	3.747	635	3.754	640	3.761	645	3.768
650	3.775	655	3.782	660	3.789	665	3.796	670	3.803
675	3.810	680	3.817	685	3.824	690	3.831	695	3.838
700	3.844	705	3.851	710	3.858	715	3.864	720	3.871
725	3.878	730	3.884	735	3.891	740	3.897	745	3.904
750	3.910	755	3.917	760	3.923	765	3.929	770	3.936
775	3.942	780	3.948	785	3.954	790	3.961	795	3.967
800	3.973	805	3.979	810	3.985	815	3.991	820	3.997
825	4.004	830	4.010	835	4.016	840	4.022	845	4.027
850	4.033	855	4.039	860	4.045	865	4.051	870	4.057
875	4.063	880	4.068	885	4.074	890	4.080	895	4.086
900	4.091	905	4.097	910	4.103	915	4.108	920	4.114
925	4.120	930	4.125	935	4.131	940	4.136	945	4.142
950	4.147	955	4.153	960	4.158	965	4.164	970	4.169
975	4.174	980	4.180	985	4.185	990	4.190	995	4.196
1000	4.201	1005	4.206	1010	4.212	1015	4.217	1020	4.222
1025	4.227	1030	4.232	1035	4.238	1040	4.243	1045	4.248
1050	4.253	1055	4.258	1060	4.263	1065	4.268	1070	4.273
1075	4.278	1080	4.284	1085	4.289	1090	4.294	1095	4.299

This table is based on the polynomials given in [1].