

Chapter six

Methodology and scope

This study has been executed over the broad subject *Physics*. The classification scheme followed in *Physics Abstracts* divides the subject *Physics* in ten major areas, of which one subject area is *Condensed Matter: Structure, Thermal and Mechanical Properties*. The scope of the present study includes the specific subject *Fermi Liquid*, under this subject area. The published research articles devoted to the area under *Fermi Liquid* covering a period of twenty years (1985-2004) as appeared in the bibliographic databases of INSPEC and COMPENDEX have been considered for this study. The keywords have been culled out from the published literature collected from the bibliographic databases INSPEC and COMPENDEX on this area for the said time span. The number of research papers devoted to this area appearing in several journals for the said time span as obtained from INSPEC and COMPENDEX is 6371. The keywords have been selected from the titles and abstracts of all these articles. The other notable feature is that only research articles have been taken for study out of the entirely available published literatures. The other forms of outcomes like monographs, conference proceedings, short communications, reviews, letters, reports, etc. have been excluded from the considered domain of the present study as the largest contribution to the full set of published literature comes only from the research articles. This exclusion however, will hardly matter to the pervasiveness and integrity of the scope of the present study. After selecting from the research articles when the keywords are organized they reveal some interesting features. The large number of keywords occurs in several groups, where each group represents a particular Keyword Cluster. A keyword cluster is thus a keyword-set consisting of alike keywords. All members of the set of similar keywords contain at least one common term, which is the indicator of the actual subject expressed by that keyword-set.

(Example: The keywords ‘Singular Fermi Liquid’, ‘Relativistic Fermi Liquid’, ‘Renormalised Fermi Liquid’ and ‘Self-consistent Fermi Liquid’ are forming a keyword cluster. The common term contained by these keywords is ‘Fermi Liquid’ and this common term also indicates the subject area dealt therein by the keyword cluster). Hence each keyword cluster represents a particular subject area, which is allied with the main subject. The number of keywords of a cluster and their total frequencies of occurrences are indicators of the volume of a keyword cluster, which again indicates the degree of correlation of the subject involved with the main subject. Hence, the larger the volume of a keyword cluster, the larger is its degree of correlation with the main subject. The remaining keywords occur isolated, as they don’t form any cluster. It is to be noted that the isolated keywords are ‘Isolated’ with respect to the subject concerned. As they don’t form any cluster with a number of identically-termed keywords, therefore they are isolated. In one subject they don’t form any cluster, but certainly they can form clusters in other subjects. Hence the ungrouped keywords are ‘Isolated’ only within a particular subject.

The following steps have been followed while selecting keywords from titles, abstracts and lists of keywords and uncontrolled terms of the research articles as available from the bibliographic databases:

- 1) Reading the title of the research paper carefully to note down insistent and significant terms.
- 2) Reading the abstract thoroughly and carefully to note down significant terms, which reflect central theme of research, discussed therein.
- 3) Reading the list of keywords and list of uncontrolled terms of the concerned research article thoroughly.
- 4) Drawing a comparative layout between the list of keywords as given in the database and the keywords as selected from the title and abstract.

- 5) Excluding those terms and keywords which are not matching the scope and purpose of the present study. (Those categories of keywords which are not taken under consideration for the present study are given below)
- 6) Let us present one sample entry from INSPEC to outline the methodologies involved in selection of keywords:

Sample Entry:

TY - JOUR

A1 - Coleman, P.

AD - Center for Mater. Theor., Rutgers Univ.,
Piscataway, NJ, USA;

A1 - Pepin, C.

M1 - Copyright 2004, IEE

PY - 2003/12/01

N2 - Using the **Schwinger boson spin representation**, we reveal a new aspect to the **physics** of a **partially screened magnetic moment** in a **metal**, as described by the **spin-S Kondo model**. We show that the **residual ferromagnetic interaction** between a **partially screened spin** and the **electron sea** destabilizes the **Landau Fermi liquid**, forming a **singular Fermi liquid behaviour** with a $1/[T \ln^4(T/K)]$ **divergence** in the **low-temperature specific heat coefficient** $C/V/T$. A magnetic field B tunes this system back into **Landau Fermi liquid** with a **Fermi temperature** proportional to $B \ln^2(T/K/B)$. We discuss a possible link with **field-tuned quantum criticality** in **heavy-electron materials**

J0 - Physical Review B (Condensed Matter and Materials Physics)

T3 - Phys. Rev., B, Condens, Matter Mater. Phys. (USA)

T1 - Singular Fermi liquid behavior in the underscreened Kondo model

KW - antiferromagnetism

KW - Fermi liquid

KW - heavy Fermion systems

KW - Kondo effect

KW - local moments

KW - specific heat

U2 - singular Fermi liquid behavior

U2 - underscreened Kondo model

U2 - Schwinger boson spin representation

U2 - partially screened magnetic moment

U2 - metal

U2 - spin-S Kondo model

U2 - residual ferromagnetic interaction

U2 - electron sea

U2 - Landau Fermi liquid

U2 - low-temperature specific heat coefficient

U2 - magnetic field tuning

U2 - Fermi temperature

U2 - field-tuned quantum criticality

U2 - heavy-electron materials

U2 - ordered moment antiferromagnetism

Explanation of the abbreviations used for field name:

TY – Type of publication;

A1 – Author;

AD – Author Affiliation;

M1 – Copyright year;
PY – Year of publication;
N2 – Abstract;
Jo – Journal name;
T3 – Abbreviation used for the journal-name;
T1 – Title of the article;
KW – Keyword
U2 – Uncontrolled term

In the sample entry eleven fields are given, out of which only four fields, viz. N2 (Abstract), T1 (Title), KW (Keyword) and U2 (Uncontrolled term) are taken under consideration for this study. The Title and Abstract are scanned meticulously first to have a broad understanding of the subject coverage for marking those keywords which are quite persevering to reflect the core central and peripheral allied theme of the subject concerned. The selected keywords are shown in the above title and abstract in bold faces. The selected keywords from Title and Abstract have been noted down, and then a comparative layout will be drawn between 'Selected' keywords and keywords which are already given in the database to make final selection. The list of keywords finally selected will be taken under consideration to carry out the present study.

Table 6.1: Keyword selection (an example)

A	B
Keywords selected from Title and Abstract	<i>Keywords already given in the Database</i>
$1/[T \ln^4/(T^3 K)]$ divergence	Antiferromagnetism
$B \ln^2/(T^3 K/B)$	Electron sea
<i>Electron sea</i>	Fermi liquid
<i>Fermi liquid</i>	Fermi temperature
<i>Fermi temperature</i>	Field-tuned quantum criticality
<i>Field-tuned quantum criticality</i>	Heavy Fermion systems
<i>Heavy-electron materials</i>	Heavy-electron materials
<i>Landau Fermi liquid</i>	Kondo effect
<i>Low-temperature specific heat coefficient C/vT</i>	Landau Fermi liquid
<i>Partially screened magnetic moment</i>	Local moments
<i>Partially screened spin</i>	Low-temperature specific heat coefficient
Physies	Magnetic field tuning (MFT)
<i>Residual ferromagnetic interaction</i>	Metal
<i>Schwinger boson spin representation</i>	Ordered moment antiferromagnetism
<i>Singular Fermi liquid behavior</i>	Partially screened magnetic moment
<i>Spin-S Kondo model</i>	Residual ferromagnetic interaction
	Schwinger boson spin representation
	Singular Fermi liquid behavior
<i>Underscreened Kondo model</i>	Specific heat
	Spin-S Kondo model
	Underscreened Kondo model

The keywords, which are selected from the Title and Abstract, are boldfaced and listed in column A of table 6.1. Some keywords are rejected from the set of selected keywords, which are left crossed out. The finally selected keywords are shown in bold italic faces. The keywords already

given in the database are listed in column B of table 6.1. Here also the rejected keywords are left crossed out and the finally selected keywords are shown in bold italic faces.

The keywords belonging to following eight categories are excluded from the scope of this study:

- 1) Too lengthy keyword (e.g. Low-temperature specific heat coefficient $C/\text{sub } V//T$, this keyword is selected after cutting off the last part)
- 2) Too common keyword (e.g. Physics)
- 3) Acronym (e.g. MFT) (Acronym is considered after expansion; e.g. Magnetic Field Tuning for MFT)
- 4) Too specific jargon (e.g. $1/[T \ln/\text{sup } 4/(T/\text{sub } K//T)]$ divergence)
- 5) Keywords not directly related with central or allied theme of the subject concerned as manifested by the abstract (e.g. Local moments)
- 6) Symbol (Not occurred here)
- 7) Formula (e.g. $B \ln/\text{sup } 2/(T/\text{sub } K//B)$)
- 8) Numerical figure (Not occurred here)

Table 6.2: Comparison between selected keywords

Keywords finally selected from Column A	Keywords finally selected from Column B
<i>Electron sea</i>	Antiferromagnetism
<i>Fermi liquid</i>	Electron sea
<i>Fermi temperature</i>	Fermi liquid
<i>Field-tuned quantum criticality</i>	Fermi temperature
<i>Heavy-electron materials</i>	Field-tuned quantum criticality
<i>Landau Fermi liquid</i>	Heavy Fermion systems
<i>Low-temperature specific heat coefficient</i>	Heavy-electron materials
<i>Partially screened magnetic moment</i>	Kondo effect
<i>Partially screened spin</i>	Landau Fermi liquid
<i>Residual ferromagnetic interaction</i>	
<i>Schwinger boson spin representation</i>	Low-temperature specific heat coefficient
<i>Singular Fermi liquid behavior</i>	Magnetic field tuning (MFT)
<i>Spin-S Kondo model</i>	Metal
	Ordered moment antiferromagnetism
	Partially screened magnetic moment
	Residual ferromagnetic interaction

The number of keywords listed in column-A and column-B are 13 and 15 respectively. A comparison between two columns reveals total number of distinct keywords, which is 19, and also avoids missing of any persistent keyword, otherwise the scope of the study will be narrow and the statistics will be poor and biased to hamper enough the main objectives. Maximum keywords occur in both columns, whereas some keywords are in column B but not in column A, i.e. they are not in title or abstract, but in the given list of keywords (assigned by the author and/or editor). All those keywords have also been considered, as they reflect light from peripheral allied

theme of the research paper. The distinct keywords selected after comparison between two columns are listed in the table 6.3 below:

Table 6.3: Distinct keywords after comparison

<i>Antiferromagnetism</i>
<i>Electron sea</i>
<i>Fermi liquid</i>
<i>Fermi temperature</i>
<i>Field-tuned quantum criticality</i>
<i>Heavy Fermion systems</i>
<i>Heavy-electron materials</i>
<i>Kondo effect</i>
<i>Landau Fermi liquid</i>
<i>Low-temperature specific heat coefficient</i>
<i>Magnetic field tuning (MFT)</i>
<i>Metal</i>
<i>Ordered moment antiferromagnetism</i>
<i>Partially screened magnetic moment</i>
<i>Partially screened spin</i>
<i>Residual ferromagnetic interaction</i>
<i>Schwinger boson spin representation</i>
<i>Singular Fermi liquid behavior</i>
<i>Spin-S Kondo model</i>

Here, the selection of keywords is being done following some specific guidelines as given below in a nutshell:

- 1) Only Words have been taken into consideration. The following entities have been excluded from the scope of the present study, viz. symbol, formula, articles, preposition, conjunction, specific jargon, numerical figure, unexpanded acronym, too general term, too lengthy term, broad subject name, brand name of any device, etc.

- 2) Only journal articles have been considered for the study.
- 3) The keywords are selected first from the title and then from the abstracts.
- 4) The keywords and uncontrolled terms as given in the database have also been noted down.
- 5) A comparative layout has been drawn between these two sets of keywords to make the final selection.
- 6) The keywords are indexed at the specific terms; the general terms are kept at last; for instance the keyword *Relativistic Fermi Liquid* has been indexed as *Fermi Liquid, Relativistic*. The indexed keywords are arranged alphabetically to group in different clusters as stipulated in the proposed taxonomy system. The entire volume of the keyword is presented in the appendix in the form as given in the bibliographic database, but not in inverted indexed form. The indexing was executed over the keyword set only for analysis.
- 7) The proper nouns are excluded from the list, (name of some eminent persons, scholars or scientists, name of place, name of country etc.) except some special cases, i.e. where any theory, method, process or device are named by the proper noun (e.g. Fermi liquid, Kondo effect, Luttinger liquid, etc.)
- 8) The keywords are indexed in singular number, but not in plural. Essential articles, prepositions and conjunctions are given in parenthesis at last.

The keywords have been filtered and put in different compartments according to the taxonomy as proposed in Chapter 3. The keyword groups

have been formed from the clustered keywords for the said time span. The clusters of keywords have five parameters:

- 1) Keyword Cluster Population: Number of keywords involved within that cluster
- 2) Keyword Cluster Frequency: Total frequency of occurrence of all keywords in the cluster concerned
- 3) Keyword Cluster Potential: Natural logarithm of the product of number of keywords involved and total frequency of occurrence of all keywords
- 4) Keyword Cluster Occurrence: Number of times the keywords occurred in the said cluster over the said time span
- 5) Keyword Cluster Rank: Rank of each cluster according to keyword cluster potential