

Low Temperature Physics (part-I)

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1. Quantum Liquids and Quantum Statistics
2. Bose-Einstein Condensation and Superfluidity
3. Lambda Transition in Liquid Helium-4 and Two-Fluid Model
4. Macroscopic Quantum Coherence and Topological Defects (quantum vortices)
5. Elementary Excitations and Microscopic Theories for Superfluid Helium-4
6. Kosterlitz-Thouless Transition
7. Magnetism of Quantum Solids (multiple spin exchange and quantum spin liquid)

References

General low temperature physics

- C. Enss and S. Hunklinger, "Low-Temperature Physics" (Springer-Verlag, Berlin-Heidelberg, 2005) (*introductory, broad topics*)

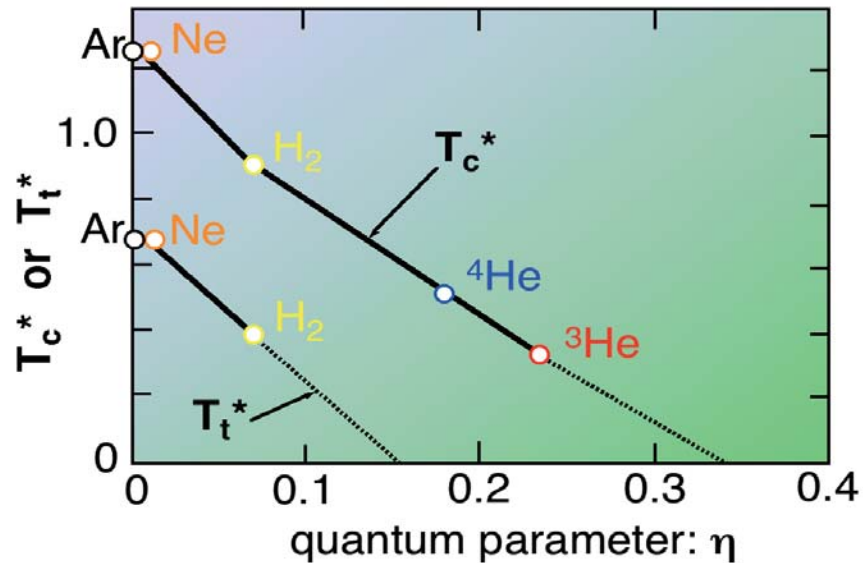
Superfluid ^4He and ^3He

- 山田一雄、大見哲巨 共著「超流動」(培風館、新物理学シリーズ28). (*standard*)
- D. R. Tilley and J. Tilley, "Superfluidity and Superconductivity" (Adam Hilger, Bristol, 1990). (*standard, broad topics*)
- E.R. Dobbs, "Helium Three" (Oxford University Press, Oxford, 2000). (*data base*)
- D. Vollhardt and P. Wölfle "The Superfluid Phases of Helium 3" (Taylor & Francis, London, 1990). (*advanced*)
- A.J. Leggett, "Quantum Liquids" (Oxford University Press, Oxford, 2006). (*advanced*)

Quantum solids

- 長岡洋介 著「超低温における固体ヘリウム」(共立出版、物理学最前線第3巻) (*standard*)
- E.R. Dobbs, "Solid Helium Three" (Clarendon Press, Oxford, 1994). (*data base*)
- M. Roger, J.H. Hetherington and J.M. Delrieu, Rev. Mod. Phys. **55**, 1-64 (1983). (*advanced*)

Quantum parameter



$$\text{Quantum parameter: } \eta \equiv \frac{K}{U} = \frac{\hbar^2/m\sigma^2}{\epsilon}$$

K : kinetic energy

U : potential energy

atom/molecule	m (amu)	$-\epsilon$ (K)	σ (nm)	η
H \uparrow (*)	1.008	6.46	0.369	0.547
^3He	3.016	10.22	0.2556	0.2409
^4He	4.003	10.22	0.2556	0.1815
H $_2$	2.016	37.0	0.292	0.0763
Ne	20.18	35.6	0.274	0.0085
Ar	39.95	120.0	0.341	0.00088
Kr	83.80	167	0.368	0.00026
Xe	131.30	225	0.407	0.000099

