

Ferromagnetic metals

Stoner model

$$\mathcal{H} = \sum_{\vec{k}, s} \epsilon_{\vec{k}} \hat{c}_{\vec{k}s}^\dagger \hat{c}_{\vec{k}s} + U \int d^3r \hat{\rho}_\uparrow(\vec{r}) \hat{\rho}_\downarrow(\vec{r})$$

kinetic energy

contact interaction
note: exchange hole

kinetic energy
versus
exchange energy

mean field treatment

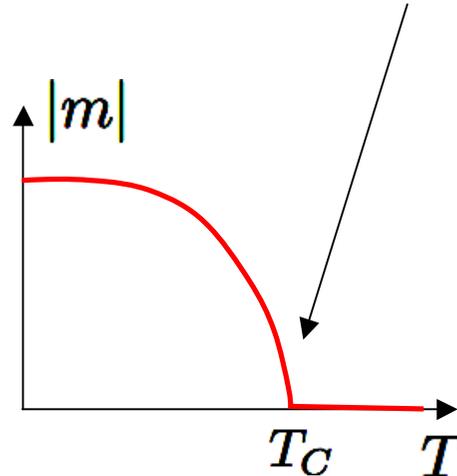
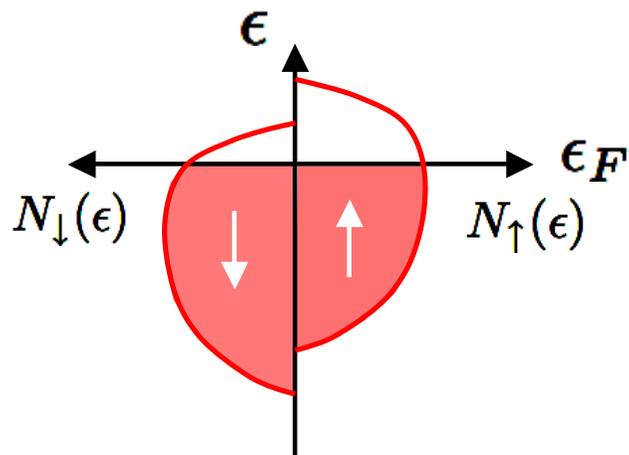
$$\hat{\rho}_s(\vec{r}) = n_s + [\hat{\rho}_s(\vec{r}) - n_s]$$

mean density of
electron with spin s

spin polarization

$$m = n_\uparrow - n_\downarrow \propto |T - T_C|^{1/2}$$

mean field
exponent



spontaneously
broken symmetries

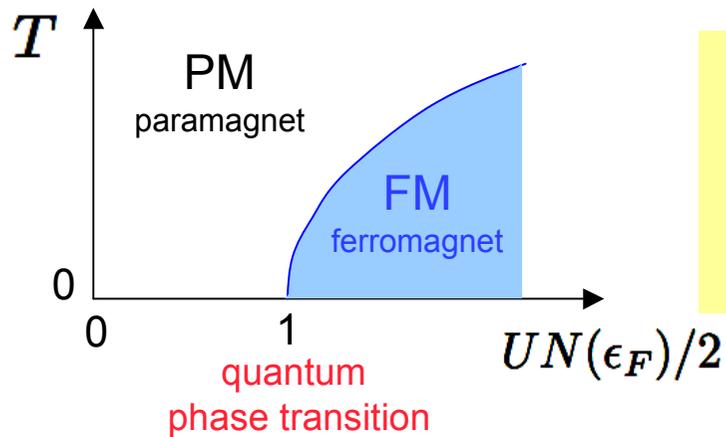
$O(3)$ rotation

\mathcal{K} time reversal

Ferromagnetic metals

$$k_B T_C \propto \sqrt{1 - \frac{U_c}{U}}$$

$$U_c N(\epsilon_F) = 2 \quad N(\epsilon) = 2 \sum_{\vec{k}} \delta(\epsilon - \epsilon_{\vec{k}})$$



Stoner criterion for FM

$$UN(\epsilon_F) > 2$$

large

$\frac{\text{exchange energy}}{\text{kinetic energy}}$

group	1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1*	Ia	IIa	IIIa**	IVa	Va	VIa	VIIa	VIIIa	IXa	Xa	Ib	IIb	IIIb	IVb	Vb	VIb	VIIb	VIIIb
1	H												B	C	N	O	F	Ne
2	Li	Be																
3	Na	Mg	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
			58	59	60	61	62	63	64	65	66	67	68	69	70	71		
			Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
			90	91	92	93	94	95	96	97	98	99	100	101	102	103		
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

3d-transition metals Fe Co Ni

4f-rare earths Gd Tb Dy Ho Er Tm

