NOPTREX

Neutron Optical Parity and Time Reversal EXperiment

Introduction to Polarized Nuclear Targets

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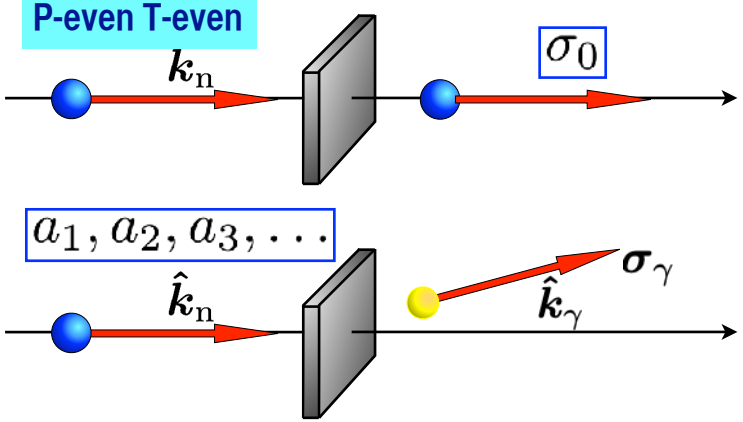
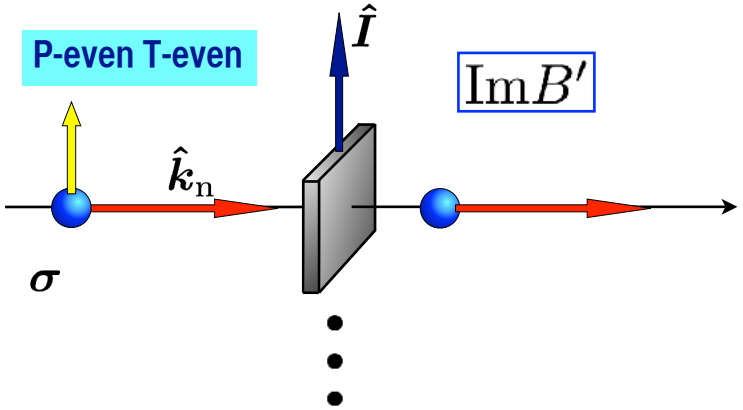
Neutron Optical Parity and Time Reversal EXperiment

Cross Section
Resonace Parameters
Reaction Mechanism

P-even T-even

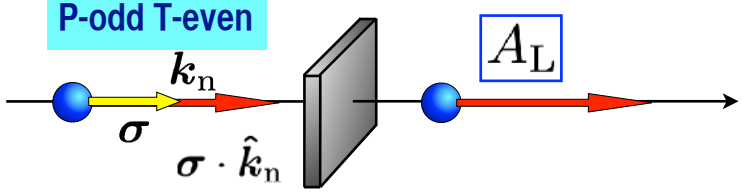


P-even T-even

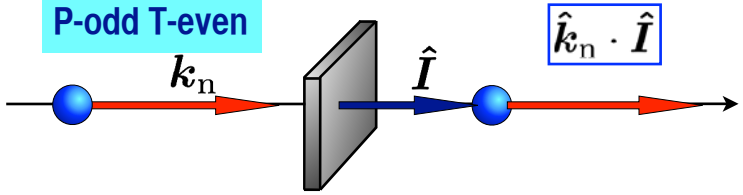


Parity Violation

P-odd T-even



P-odd T-even

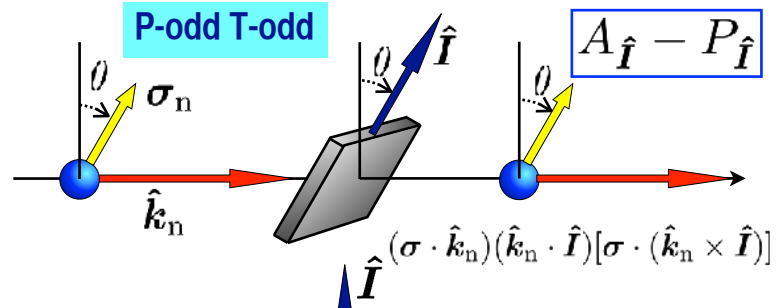


Technology

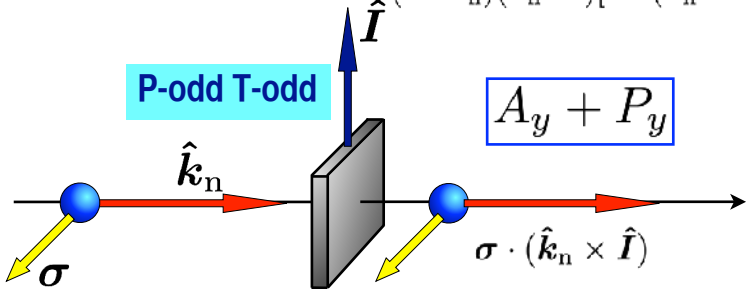
- Neutron Detector
- Neutron Spin Polarizer/Analyzer
- Neutron Spin Transport
- Polarized Target
- γ-ray Detector
- γ-ray Polarimeter
- ...

Time Reversal Violation

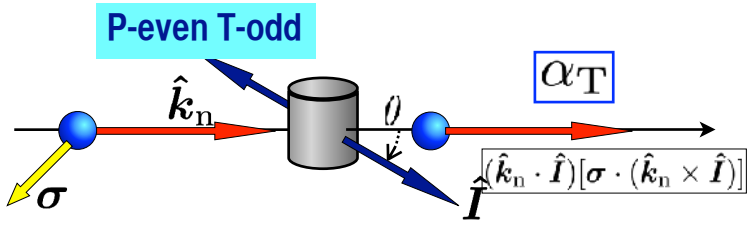
P-odd T-odd



P-odd T-odd



P-even T-odd



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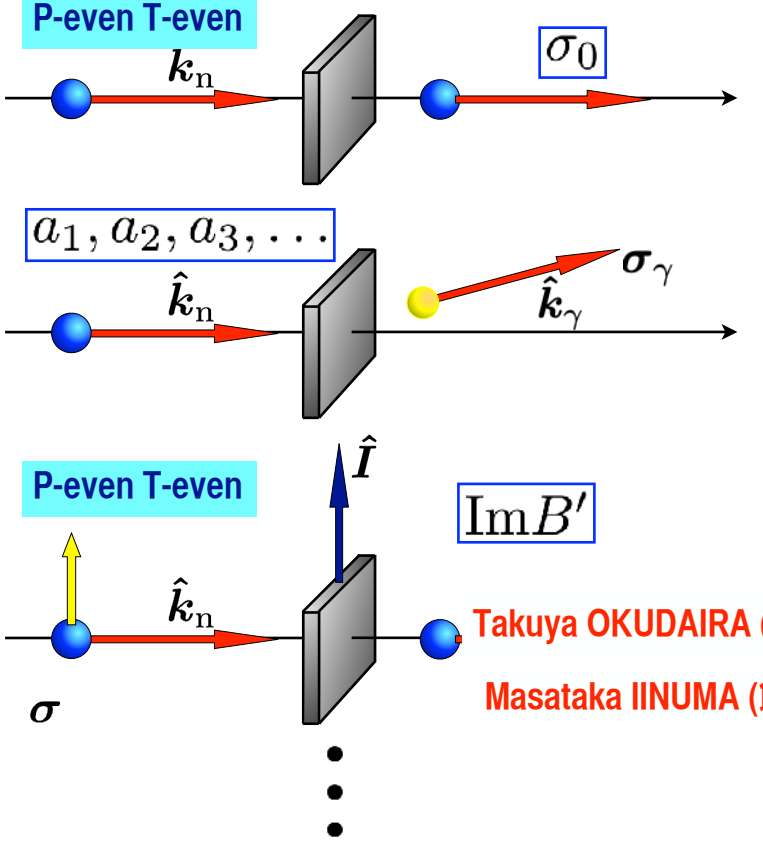


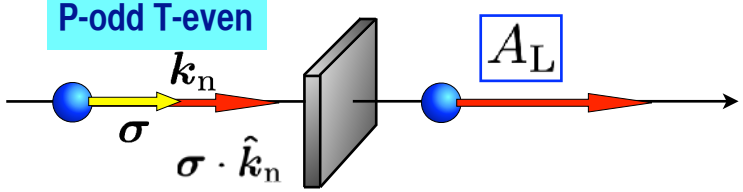
P-even T-even

Takuya OKUDAIRA (奥平 琢也)

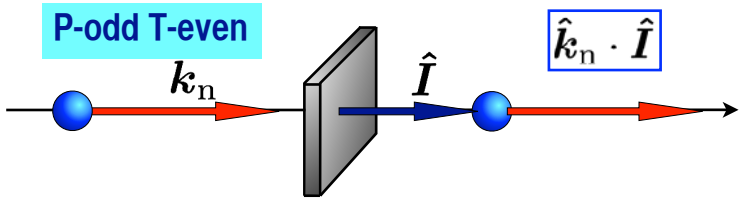
Masataka IINUMA (飯沼 昌隆)

Parity Violation

P-odd T-even



P-odd T-even



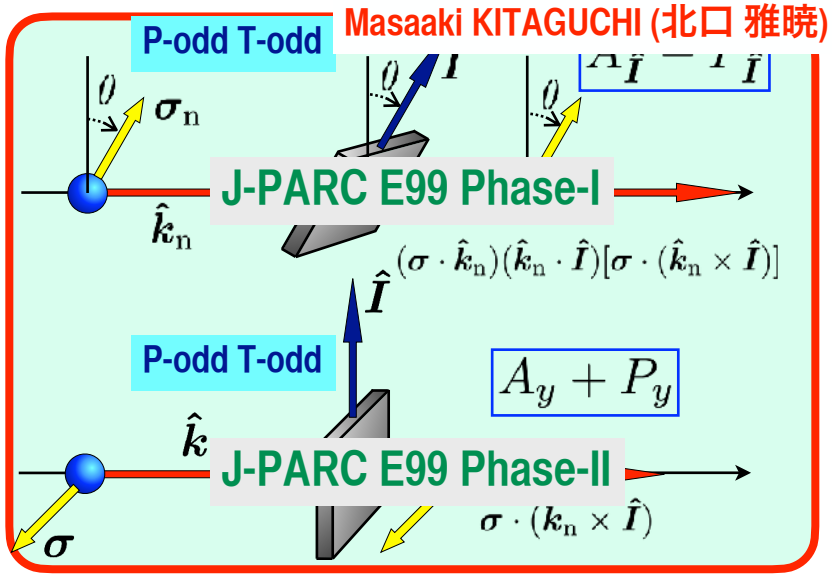
Technology

- Neutron Detector
- Neutron Spin Polarizer/Analyzer
- Neutron Spin Transport
- Polarized Target
- γ-ray Detector
- γ-ray Polarimeter
- ...

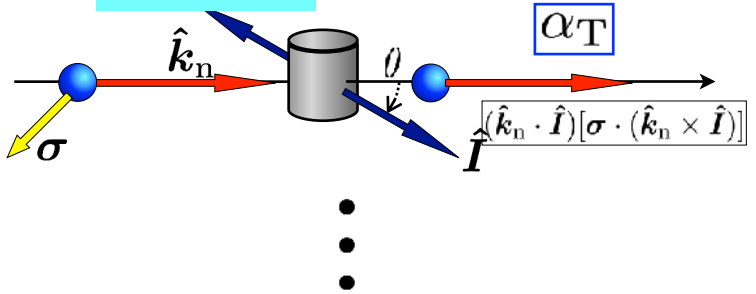
Time Reversal Violation

Masaaki KITAGUCHI (北口 雅暁)

P-odd T-odd



P-even T-odd



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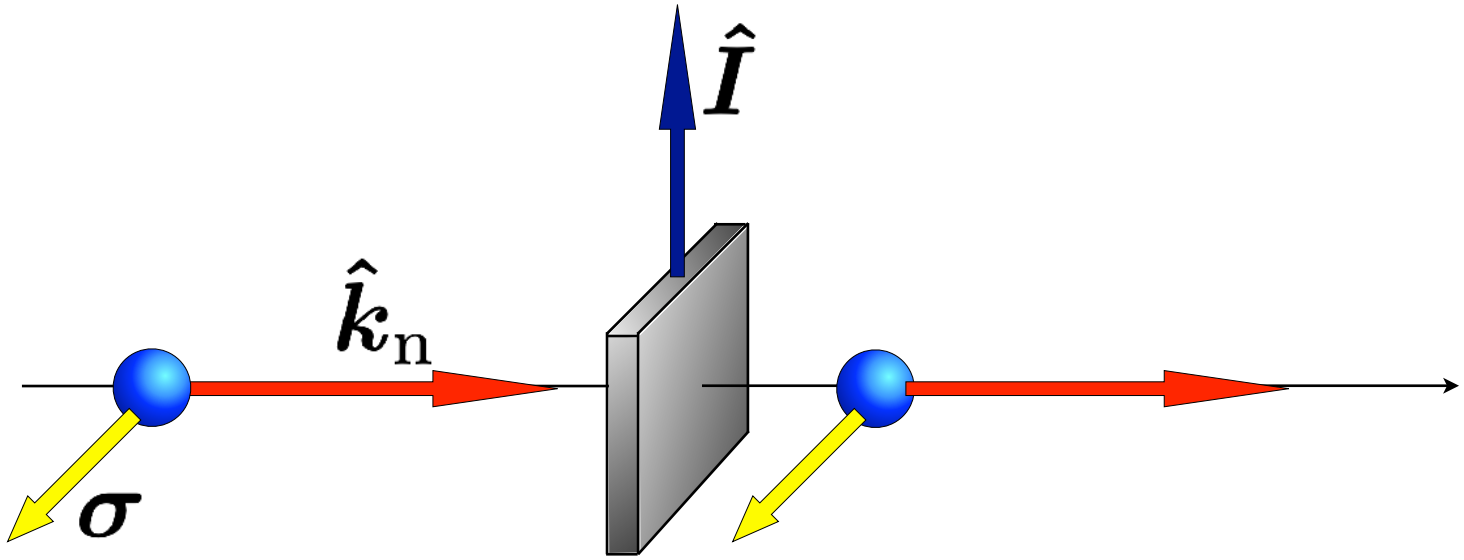


function	Neutron Spin Polarizer	Polarized Target	Neutron Spin Analyzer
device	Polarized ^{3}He	Polarized ^{139}La	Polarized ^{3}He
method	SEOP (Spin Exchange Optical Pumping)	DNP (Dynamic Nuclear Polarization)	SEOP (Spin Exchange Optical Pumping)

Polarized Proton
DNP (Dynamic Nuclear Polarization)

alternative solution for higher energy

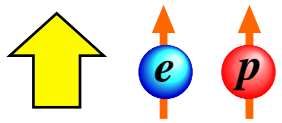
Polarized Proton
DNP (Dynamic Nuclear Polarization)

Nuclear Polarization in Solid
固体中の核偏極

major methods to polarize nuclei in solid

Brute-force Method 静的核偏極

B~10T
T≤0.1K

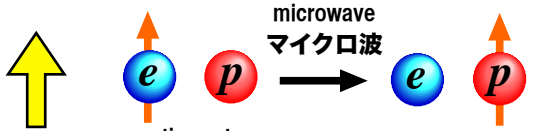


熱平衡

Dynamic Nuclear Polarization (DNP) 動的核偏極

polarization of paramagnetic centers is transferred to nuclei via forbidden transition induced by microwave irradiation

B~2-5T
T≤1K

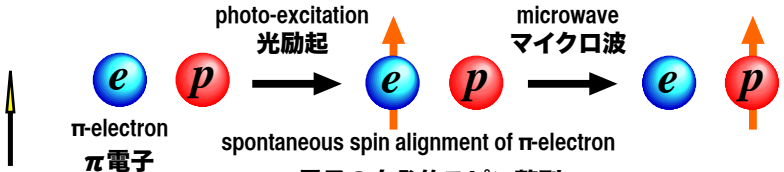


paramagnetic center
at thermal equilibrium

常磁性中心　熱平衡　　熱非平衡

Microwave-Induced Optical Nuclear Polarization (MIONP)
Triplet-DNP 三重項光励起動的核偏極

B~0.3T
T≤77K
(⇧300K)



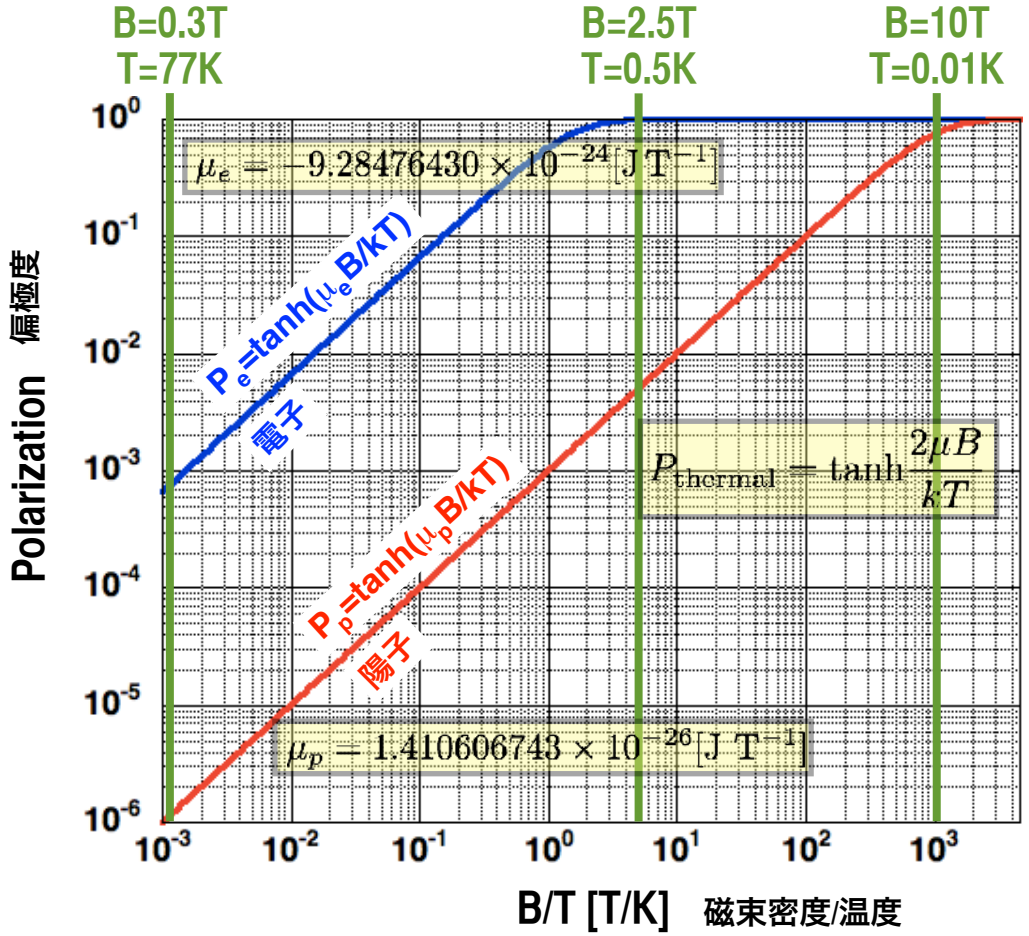
π-electron
π電子

spontaneous spin alignment of π-electron
π電子の自発的スピン整列

熱非平衡　　熱非平衡

apparent polarization of a pair of specific magnetic substates of π-electrons in aromatic organic molecules is transferred to near-by nuclei via forbidden transition induced by microwave irradiation

nuclear polarization at thermal equilibrium
熱平衡下での核偏極度

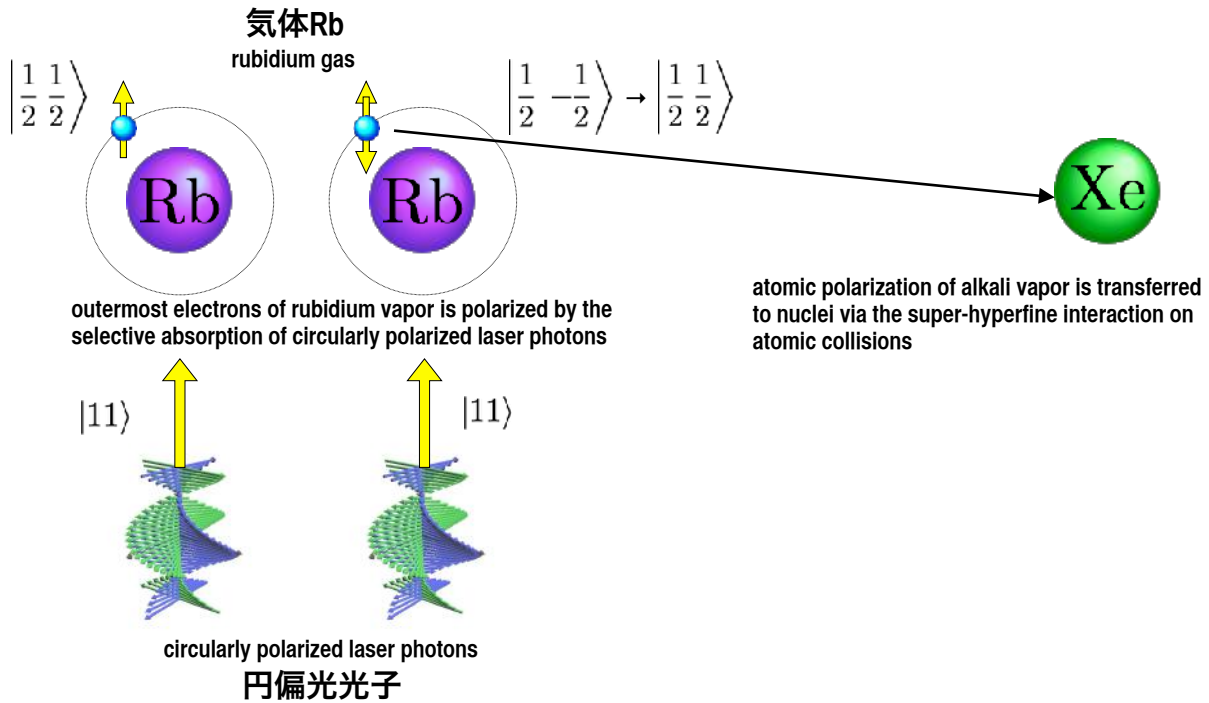


Nuclear Polarization in Confined Gas
封入された気体中の核偏極

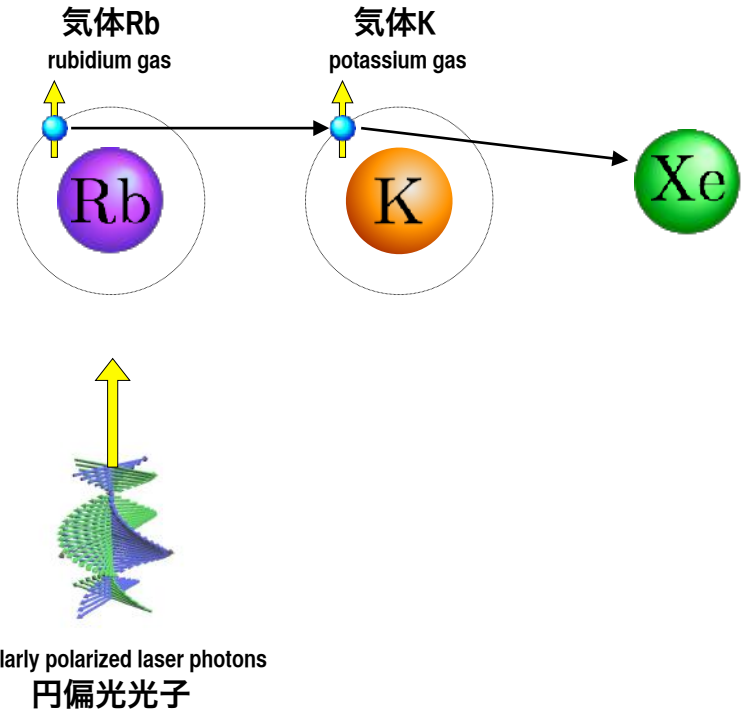
major method to polarize nuclei in confined gas

Spin Exchange Optical Pumping (SEOP)　スピン交換光ポンピング

B ~1 mT
T ~ 450 K



Hybrid SEOP



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2024/08/20

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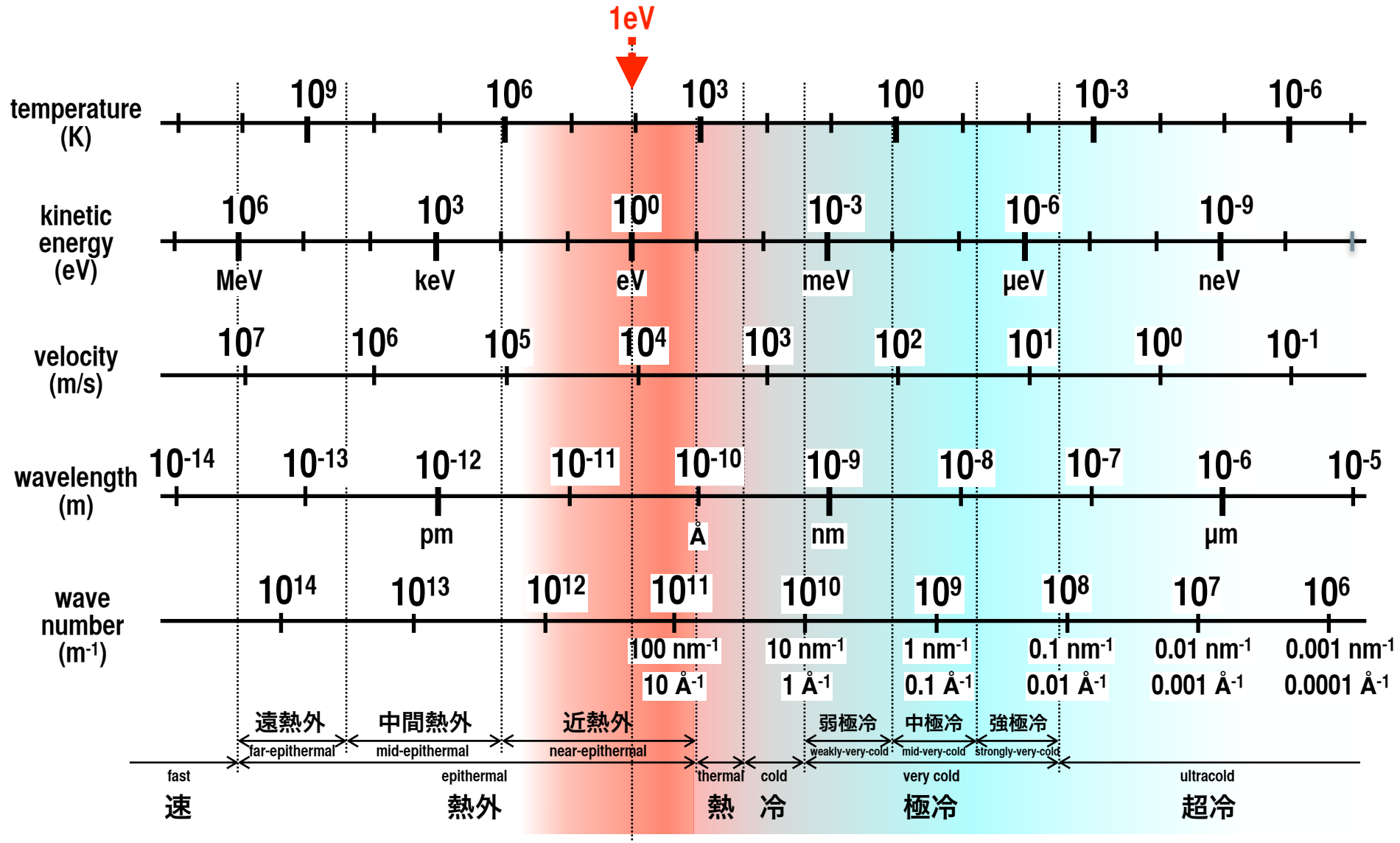
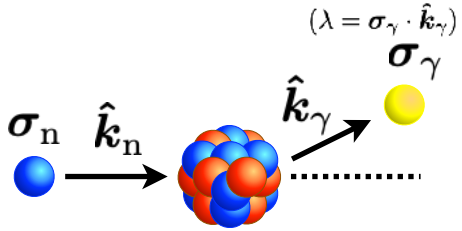
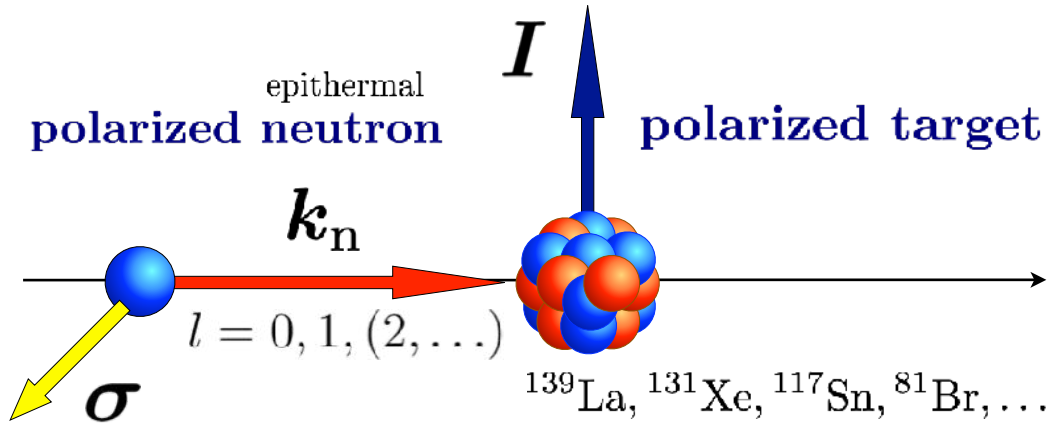
Wayne State Univ. E.Y.Chekmenev

Neutrons conversions among kinematic variables and an example of energy range names







$$f = \underbrace{A'}_{\text{P-even T-even}} + P_1 \underbrace{H'}_{\text{P-odd T-even}} (\hat{\boldsymbol{k}}_n \cdot \hat{\boldsymbol{I}}) + P_2 \underbrace{E'}_{\text{P-even T-even}} \left((\hat{\boldsymbol{k}}_n \cdot \hat{\boldsymbol{I}})^2 - \frac{1}{3} \right)$$

$$+ (\boldsymbol{\sigma} \cdot \hat{\boldsymbol{I}}) \left\{ P_1 \underbrace{B'}_{\text{P-even T-even}} + P_2 \underbrace{F'}_{\text{P-odd T-even}} (\hat{\boldsymbol{k}}_n \cdot \hat{\boldsymbol{I}}) + P_3 \underbrace{\frac{B'_3}{3}}_{\text{P-even T-even}} \left((\hat{\boldsymbol{k}}_n \cdot \hat{\boldsymbol{I}})^2 - 1 \right) \right\}$$

$$+ (\boldsymbol{\sigma} \cdot \hat{\boldsymbol{k}}_n) \left\{ \underbrace{C'}_{\text{P-odd T-even}} + P_1 \underbrace{K'}_{\text{P-even T-even}} (\hat{\boldsymbol{k}}_n \cdot \hat{\boldsymbol{I}}) - P_2 \underbrace{\frac{F'}{3}}_{\text{P-odd T-even}} + P_3 \underbrace{\frac{2B'_3}{3}}_{\text{P-even T-even}} (\hat{\boldsymbol{k}}_n \cdot \hat{\boldsymbol{I}}) \right\}$$

$$+ (\boldsymbol{\sigma} \cdot (\hat{\boldsymbol{k}}_n \times \hat{\boldsymbol{I}})) \left(P_1 \underbrace{D'}_{\text{P-odd T-odd}} + P_2 \underbrace{G'}_{\text{P-even T-odd}} (\hat{\boldsymbol{k}}_n \cdot \hat{\boldsymbol{I}}) \right)$$