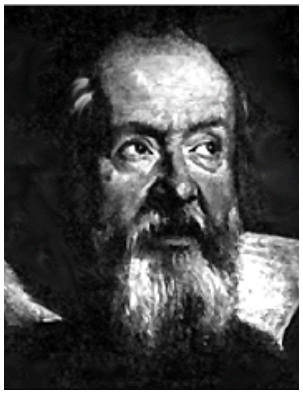
Unification of sciences

A —— P C B

Johannes Kepler
1602, 1609, 1619



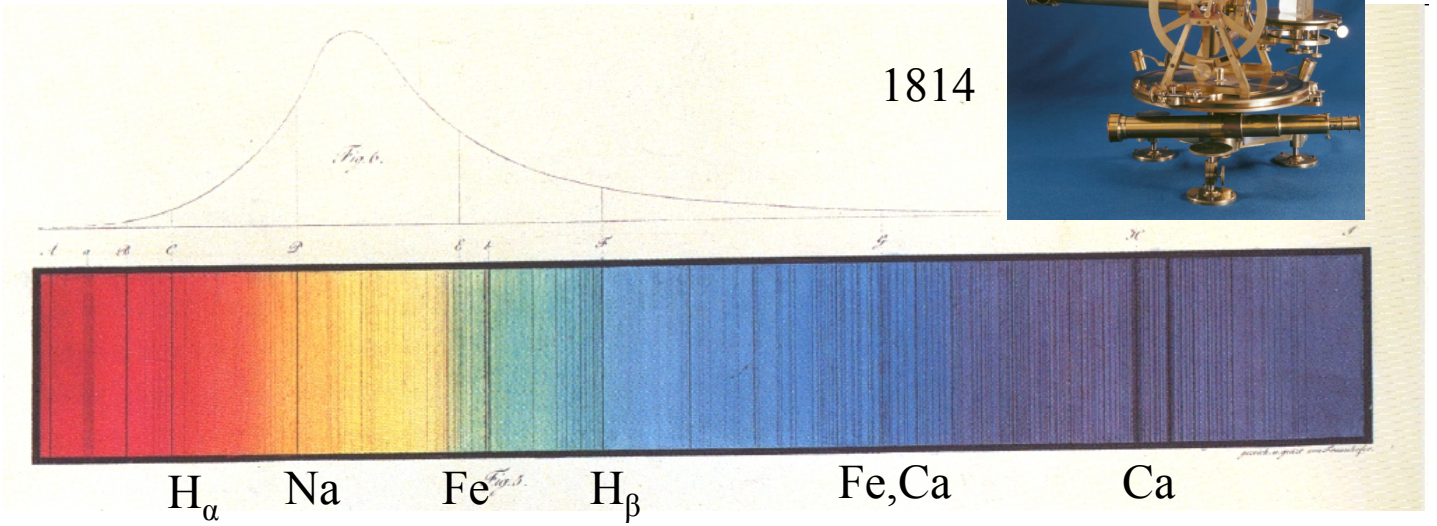
Galileo Galilei
1590, 1638

Isaac Newton
1666, 1687

A — P — C — B

Spectroscopy

Joseph von Fraunhofer
1787 – 1826



Bestimmung des Brechungs- und Farbenzerstreuungs-Vermögens
verschiedener Glasarten,
in Bezug auf die Vervollkommung achromatischer Fernröhre
Denkschriften der königlichen Akademie
der Wissenschaften zu München, V., 193-226, 1817

Mars, Venus, Sirius, Castor, Pollux, Capella, Betelgeuse, Procyon

"The most remarkable discovery in all of astronomy is that
the stars are made of atoms of the same kind as those on the earth."
Feynman Lectures on Physics I, 3-6 (1963)

Approximavit Sidera

(2) Orders of magnitude and symmetry the two pillars of spectroscopy

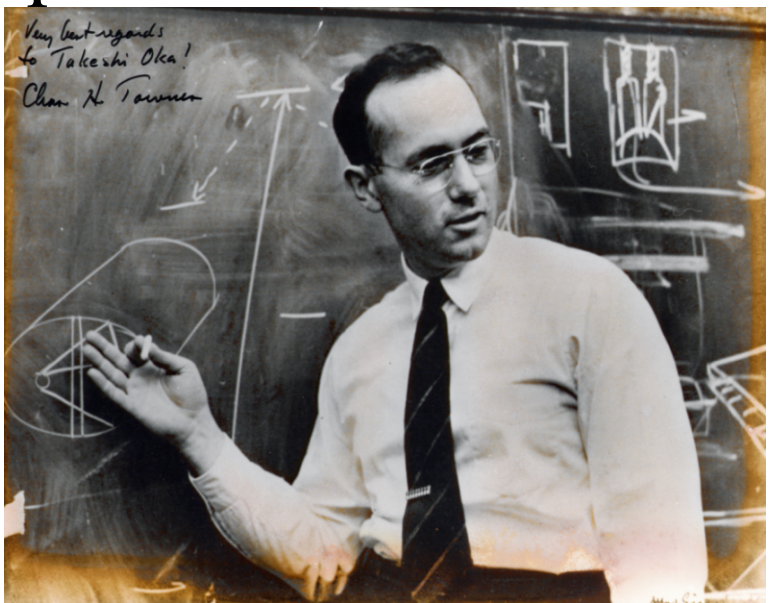
September 26, Monday 14:00 -

Orders of magnitude

quantitative and approximate

Symmetry

qualitative and accurate



Charles H. Townes 1915-2015

Koichi Shimoda
1920 -

Natural constants

dimensionless constants

e electromagnetics

c special relativity

$\hbar$ quantum mechanics

$$\alpha = \frac{e^2}{\hbar c} \approx \frac{1}{137}$$

Fine structure constant

Sommerfeld 1916

m_e

M

$$\kappa = \sqrt[4]{\frac{m_e}{M}} \sim \frac{1}{10}$$

Born-Oppenheimer constant

Born & Oppenheimer 1927

G gravitation, general relativity

$$M_{\text{Chandra}} = k \cdot \left(\frac{\hbar c}{G}\right)^{\frac{3}{2}} \frac{1}{M_{\text{H}}^2}$$

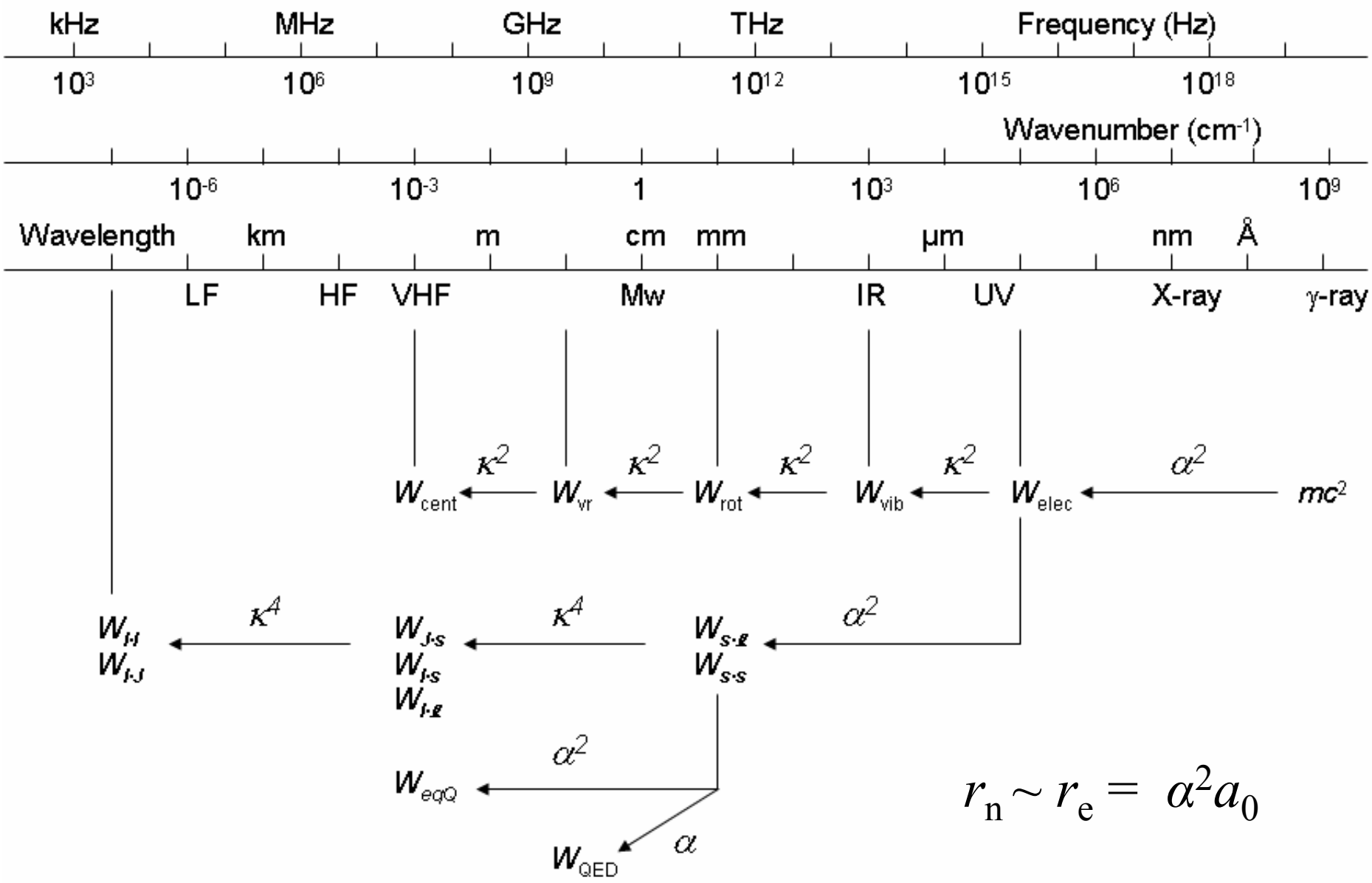
Fine structure constant $\frac{e^2}{\hbar c}$

$$\frac{e^2}{r^2} = \frac{mv^2}{r}$$

$$mrv = \hbar$$

$$\alpha = \frac{e^2}{\hbar c} \sim \frac{v}{c}$$

$$W = \frac{mc^2}{\sqrt{1 - v^2/c^2}} = mc^2\left(1 + \frac{1}{2}\alpha^2 + \frac{3}{8}\alpha^4 + \cdots\right)$$



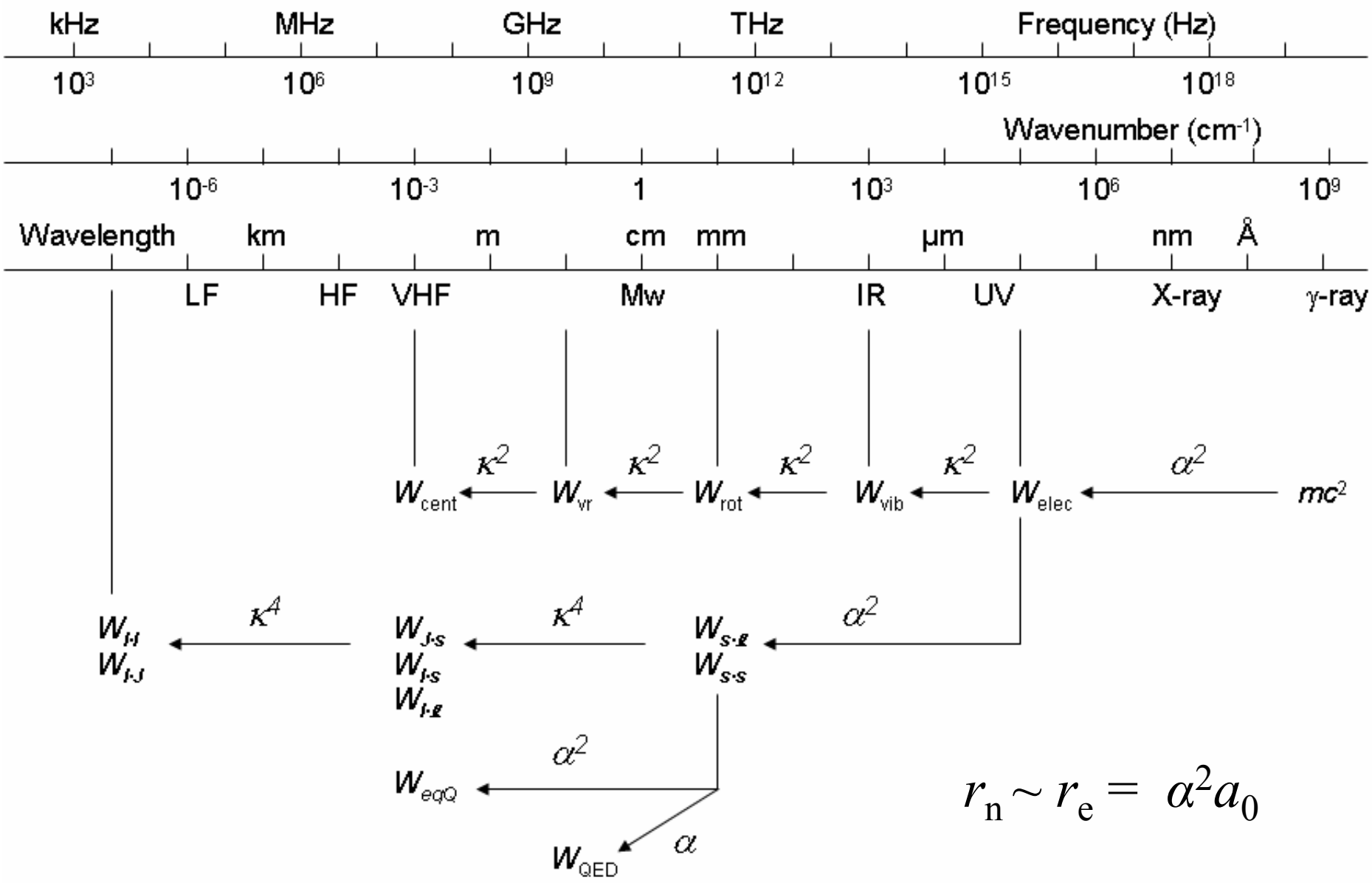
$$r_n \sim r_e = \alpha^2 a_0$$

The Born Oppenheimer constant

$$\kappa = \sqrt[4]{\frac{m_e}{M}} \sim 0.1$$

$$W_{\mathrm{rot}} = \kappa^4 W_{\mathrm{e}}$$

J. Chem. Phys. 47, 5410 (1967)



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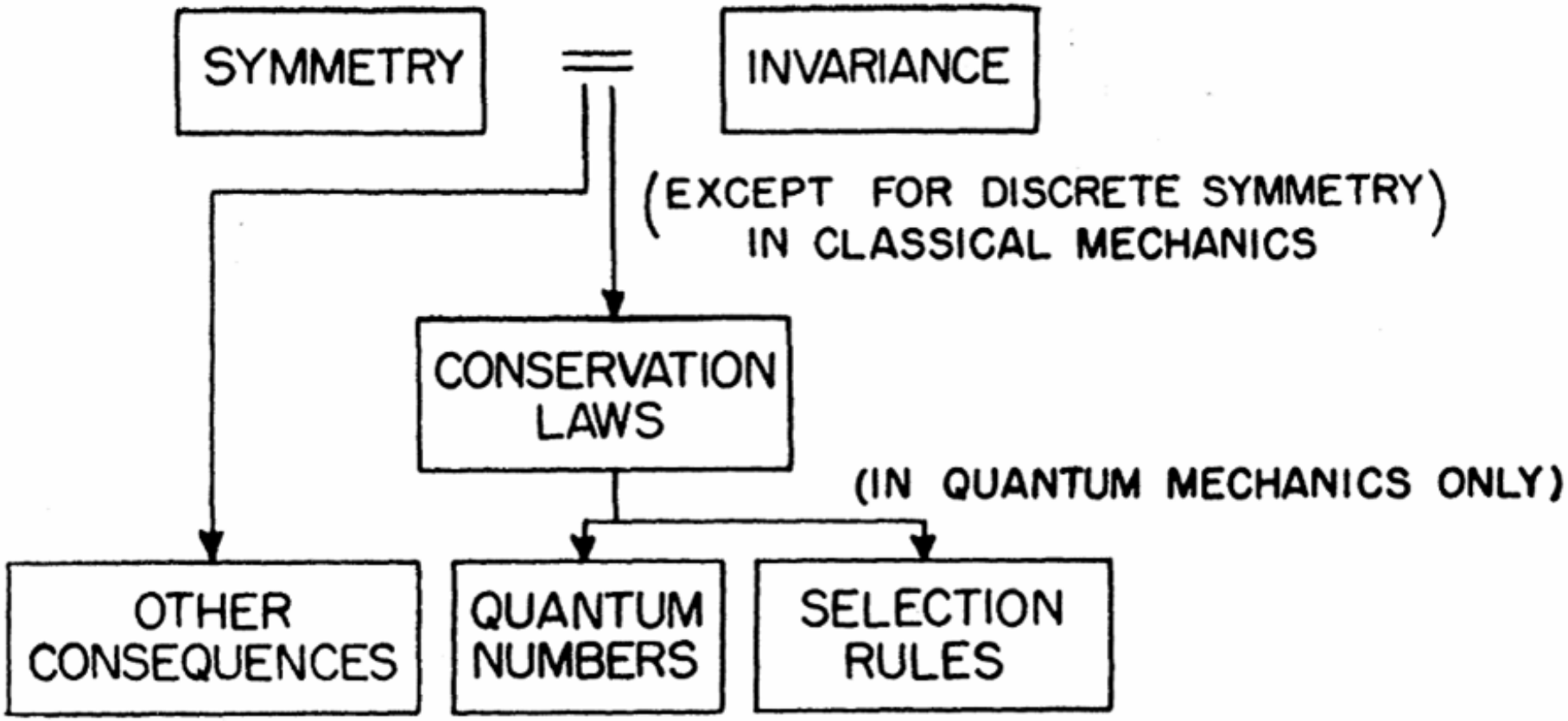

The root of all symmetry principles lies in the assumption that it is impossible to observe certain basic quantities; these will be called 'non-observables'.

Lee (1981)

1. Continuous space-time symmetry:
   (a) time translation $t \to t + \tau$ (absolute time).
   (b) space translation $\boldsymbol{r} \to \boldsymbol{r} + \boldsymbol{\rho}$ (origin of space).
   (c) space rotation $\boldsymbol{r} \to \boldsymbol{D}\boldsymbol{r}$ (absolute direction).
2. Discrete space-time symmetry:
   (d) space inversion $\boldsymbol{r} \to -\boldsymbol{r}$ (absolute left and right).
   (e) time reversal $t \to -t$ (absolute direction of motion).
3. Permutation of identical particles (difference between identical particles).