

Particle Physics II

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Albert-Ludwigs-Universität Freiburg



Prof. Markus Schumacher

Physikalisches Institut, Westbau, 2. OG Room 008

Phone 07621 203 7612

E-Mail: Markus.Schumacher@physik.uni-freiburg.de

<http://terascale.physik.uni-freiburg.de/lehre/>

Chapter 0

Introduction

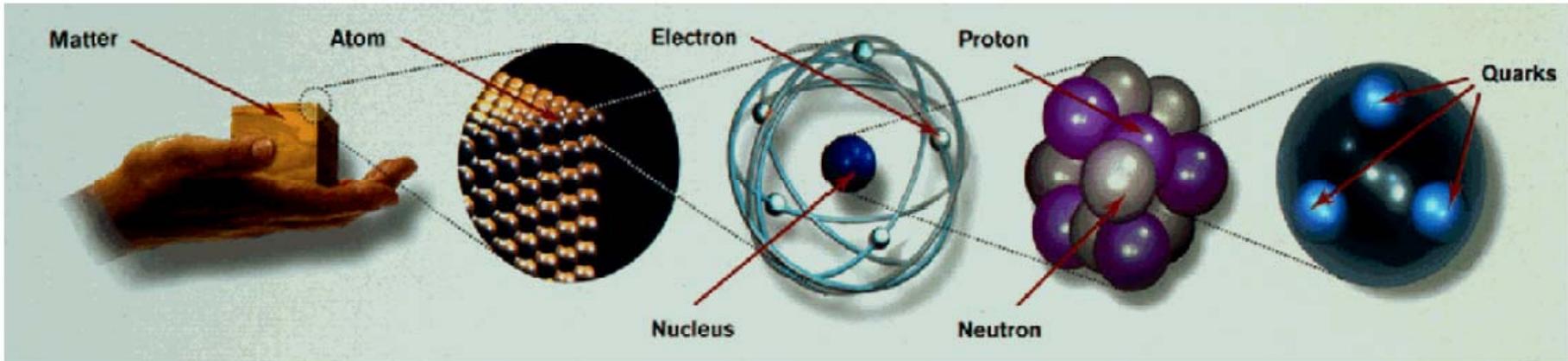
“Elementary” is time dependent

from the Greeks
until ~ 1850

1920

1930

~ 1970



$\sim 10^{-2}$ m

$\sim 10^{-8}$ m

$\sim 10^{-10}$ m

$\sim 10^{-14}$ m

$\sim 10^{-15}$ m

Atom

Nucleus

Proton, Neutron

$< 10^{-18}$ m

Quarks

Space Dimension



now

Time

300 000 years

100 s 1s

BB

Constituents of matter

Teilchen

Antiteilchen

Leptonen:	$\begin{pmatrix} \nu_e \\ e^- \end{pmatrix}$	$\begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix}$	$\begin{pmatrix} \nu_\tau \\ \tau^- \end{pmatrix}$	charge	$\begin{pmatrix} \bar{\nu}_e \\ e^+ \end{pmatrix}$	$\begin{pmatrix} \bar{\nu}_\mu \\ \mu^+ \end{pmatrix}$	$\begin{pmatrix} \bar{\nu}_\tau \\ \tau^+ \end{pmatrix}$
Quarks:	$\begin{pmatrix} u^{\frac{2}{3}} \\ d^{-\frac{1}{3}} \end{pmatrix}$	$\begin{pmatrix} c^{\frac{2}{3}} \\ s^{-\frac{1}{3}} \end{pmatrix}$	$\begin{pmatrix} t^{\frac{2}{3}} \\ b^{-\frac{1}{3}} \end{pmatrix}$		$\begin{pmatrix} \bar{u}^{-\frac{2}{3}} \\ \bar{d}^{+\frac{1}{3}} \end{pmatrix}$	$\begin{pmatrix} \bar{c}^{-\frac{2}{3}} \\ \bar{s}^{+\frac{1}{3}} \end{pmatrix}$	$\begin{pmatrix} \bar{t}^{-\frac{2}{3}} \\ \bar{b}^{+\frac{1}{3}} \end{pmatrix}$

symmetry:

- 3 families
- every particle has an anti-particle
 - same mass
 - opposite charge

Masses of elementary particles

Quarks



Up

Masse ~ 4 MeV



Charm

Masse ~ 1,3 GeV



Top

Masse ~ 174 GeV

Elektr. Ladung $+\frac{2}{3}$



Down

Masse ~ 8 MeV



Strange

Masse ~ 130 MeV



Bottom

Masse ~ 4,4 GeV

Elektr. Ladung $-\frac{1}{3}$

Leptonen



Elektron

Masse 511 keV



Myon

Masse 105 MeV



Tau

Masse 1,8 GeV

Elektr. Ladung -1



Elektron-Neutrino

Masse < 3 eV



Myon-Neutrino

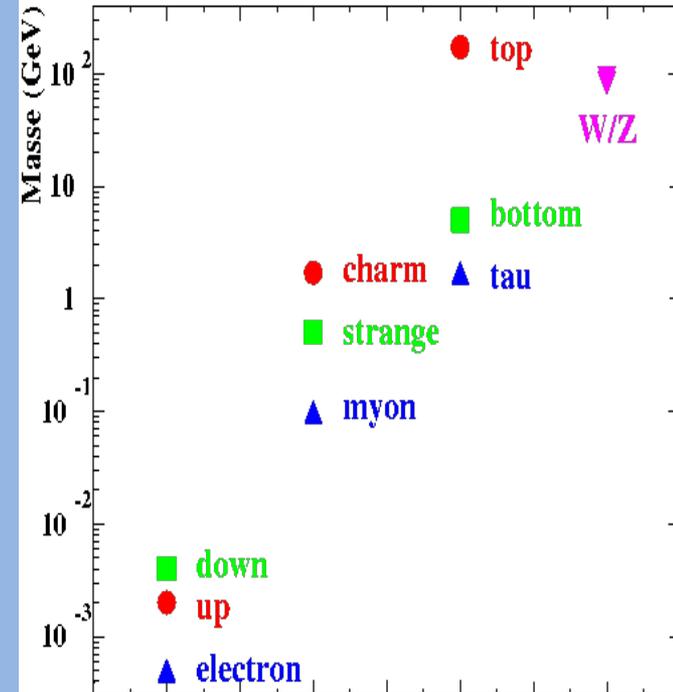
Masse < 190 keV



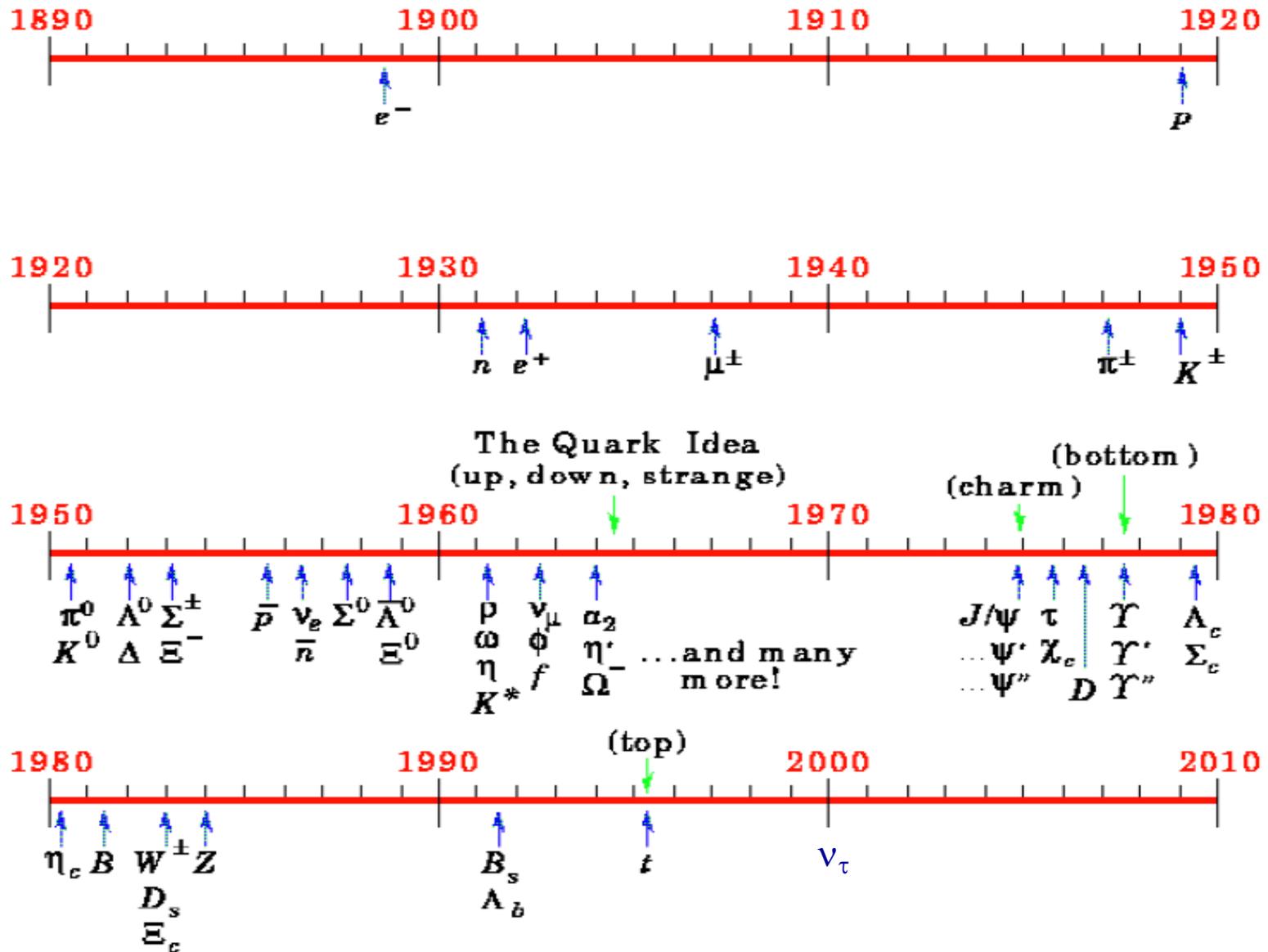
Tau-Neutrino

Masse < 18 MeV

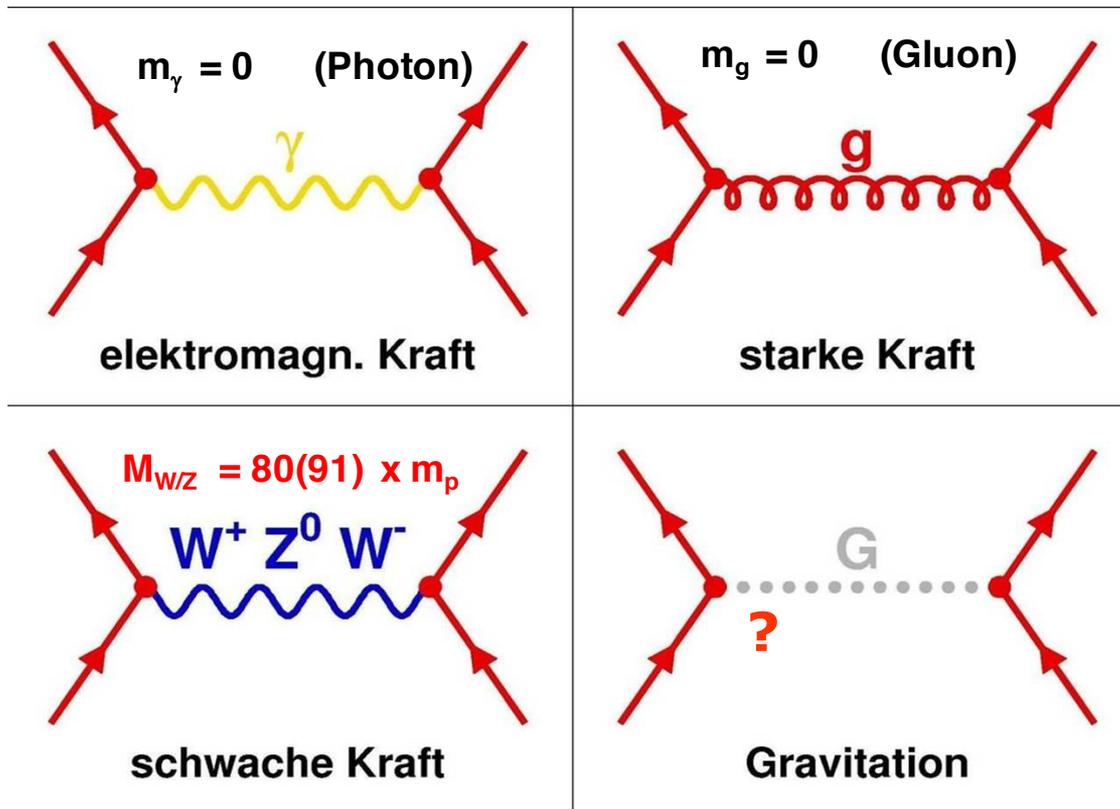
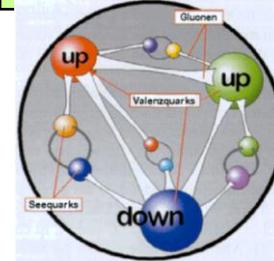
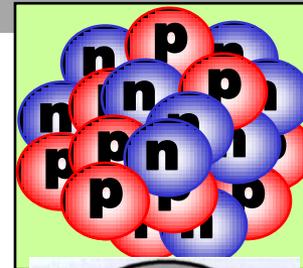
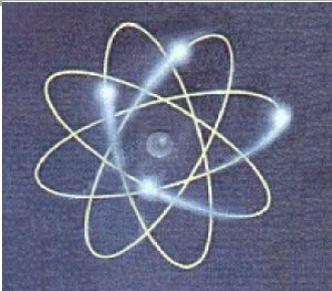
Elektr. Ladung 0



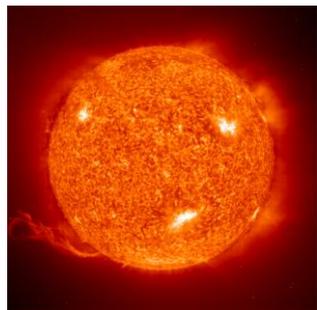
Timeline of discoveries



Interactions and Messenger particles



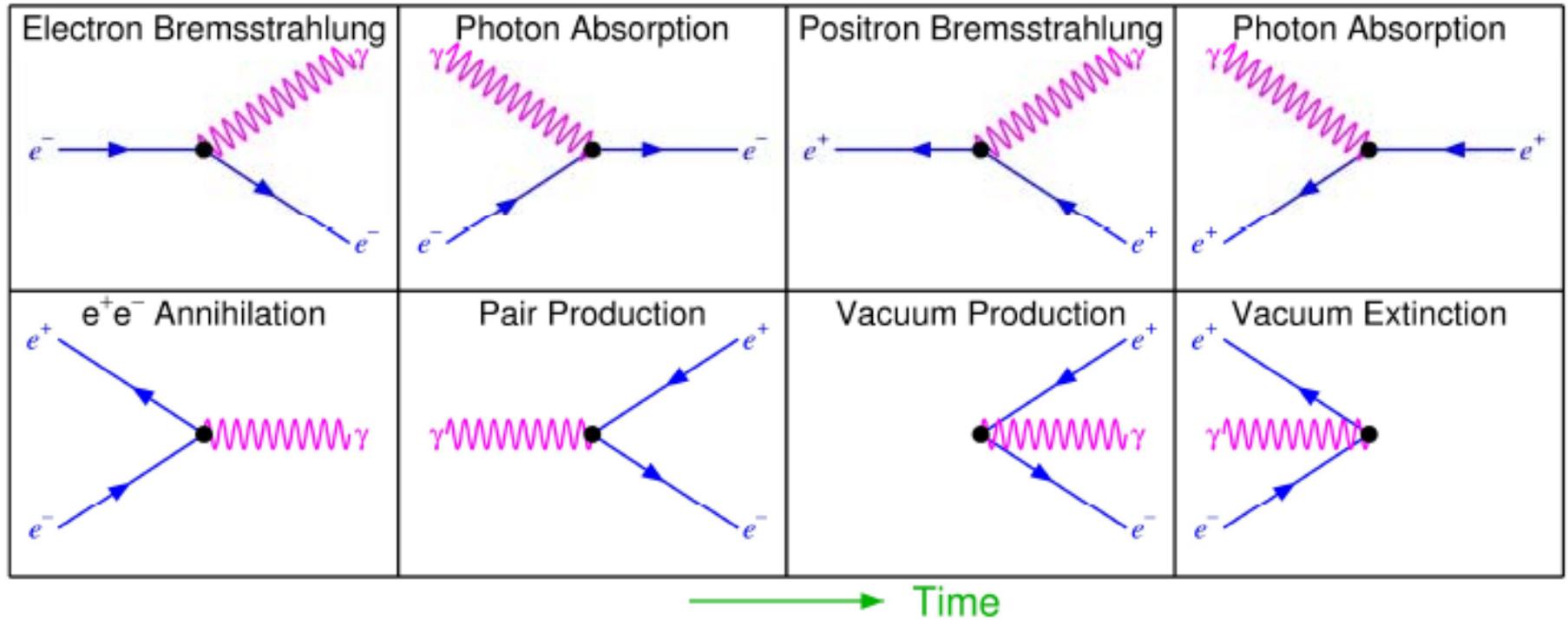
Stärke 1/10000
x el-mag. Kraft



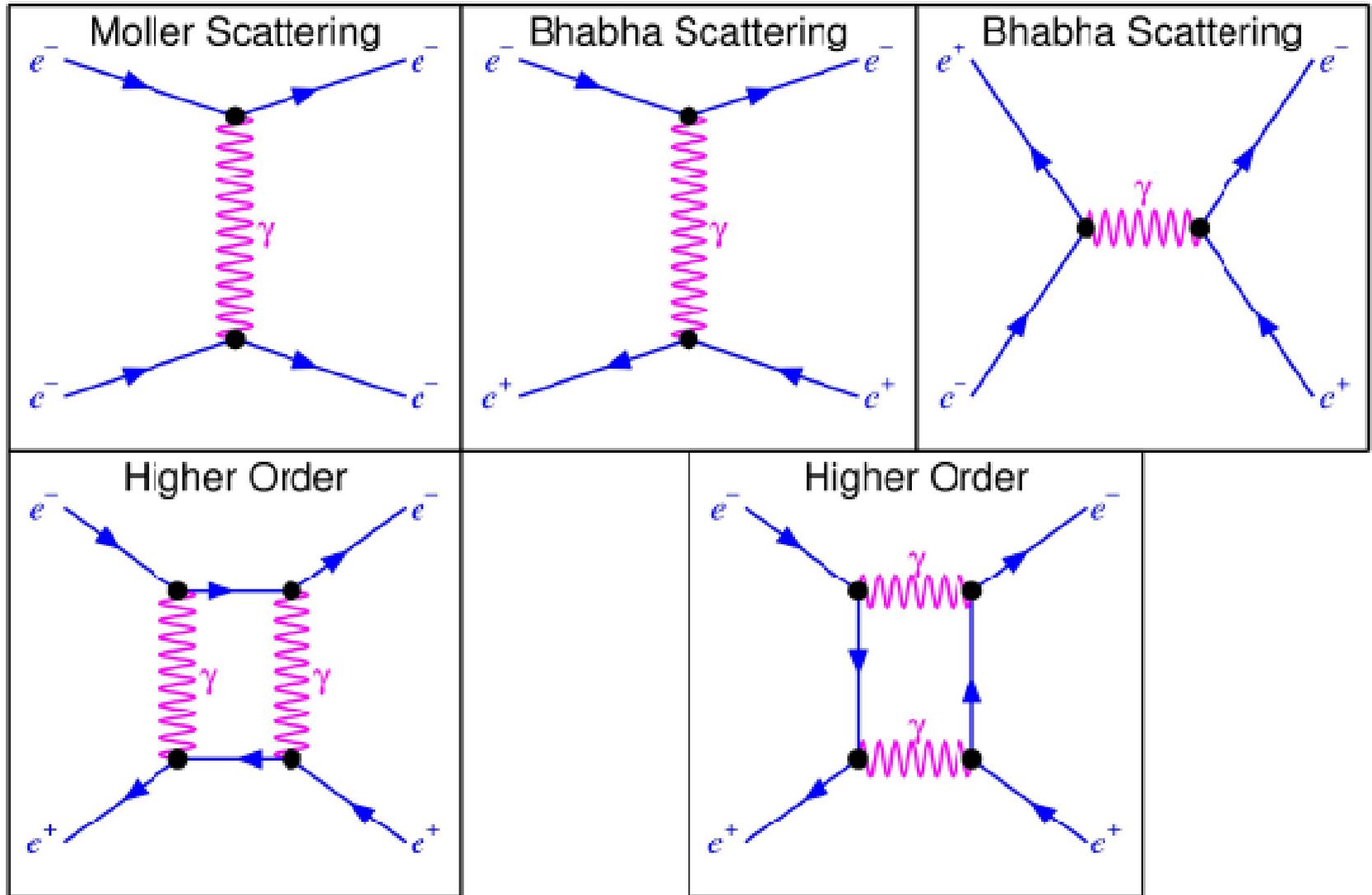
Bosonen	8 Gluonen	W^+, W^-, Z	γ
Gruppe	SU(3)	SU(2)	U(1)
Theorie	starke Kraft	schwache Kraft	elektromagnetische Kraft
	QCD		QED

Beschreibung der Wechselwirkungen
beruht auf abstrakten Symmetrien
→ Quantenfeldtheorie

Feynmandiagrams of QED

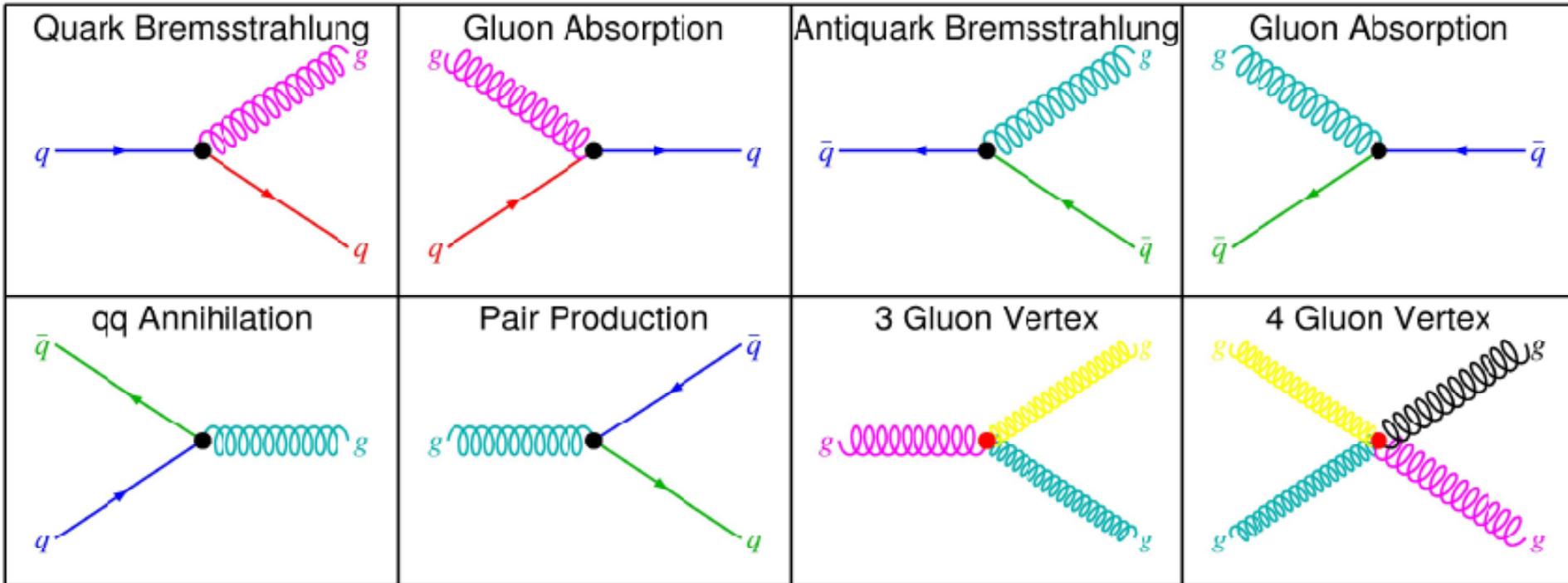


Feynman Diagrams of QED

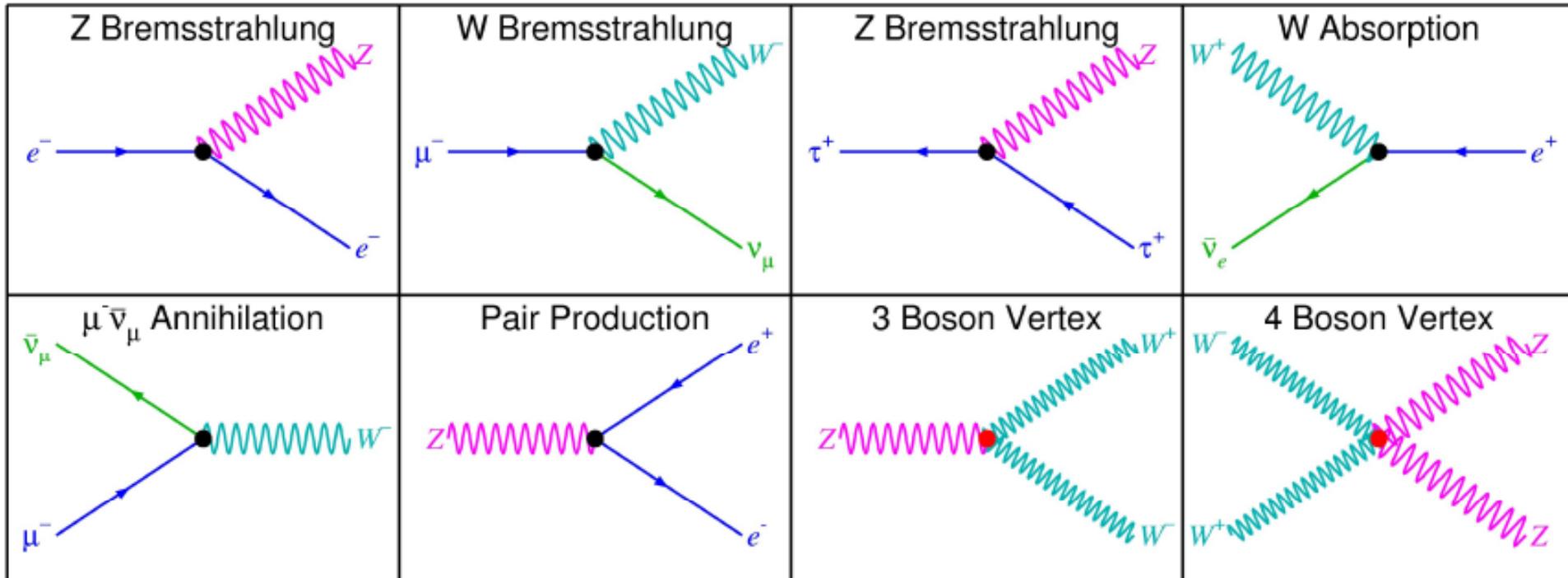


→ Time

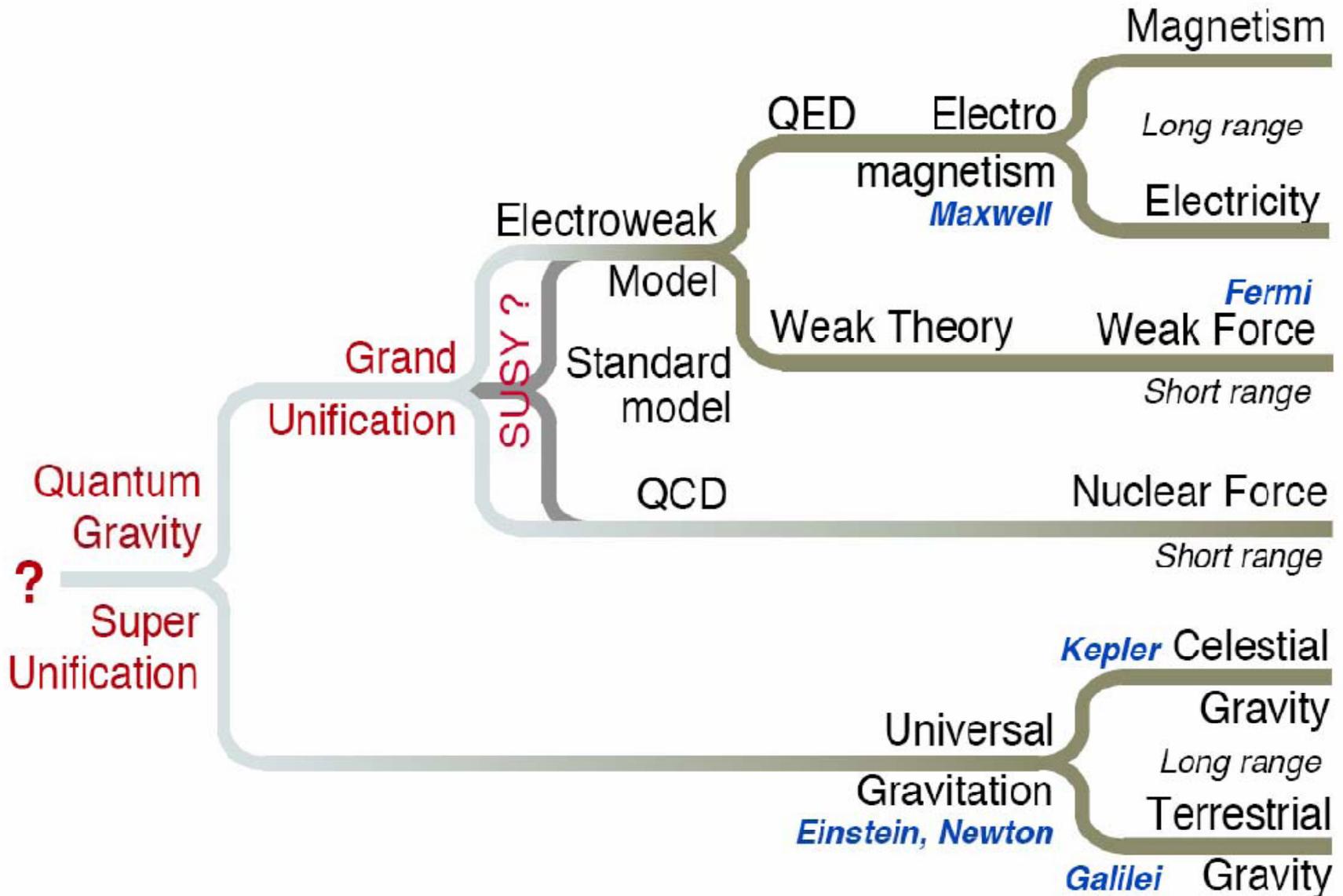
Feynman Diagrams of QCD



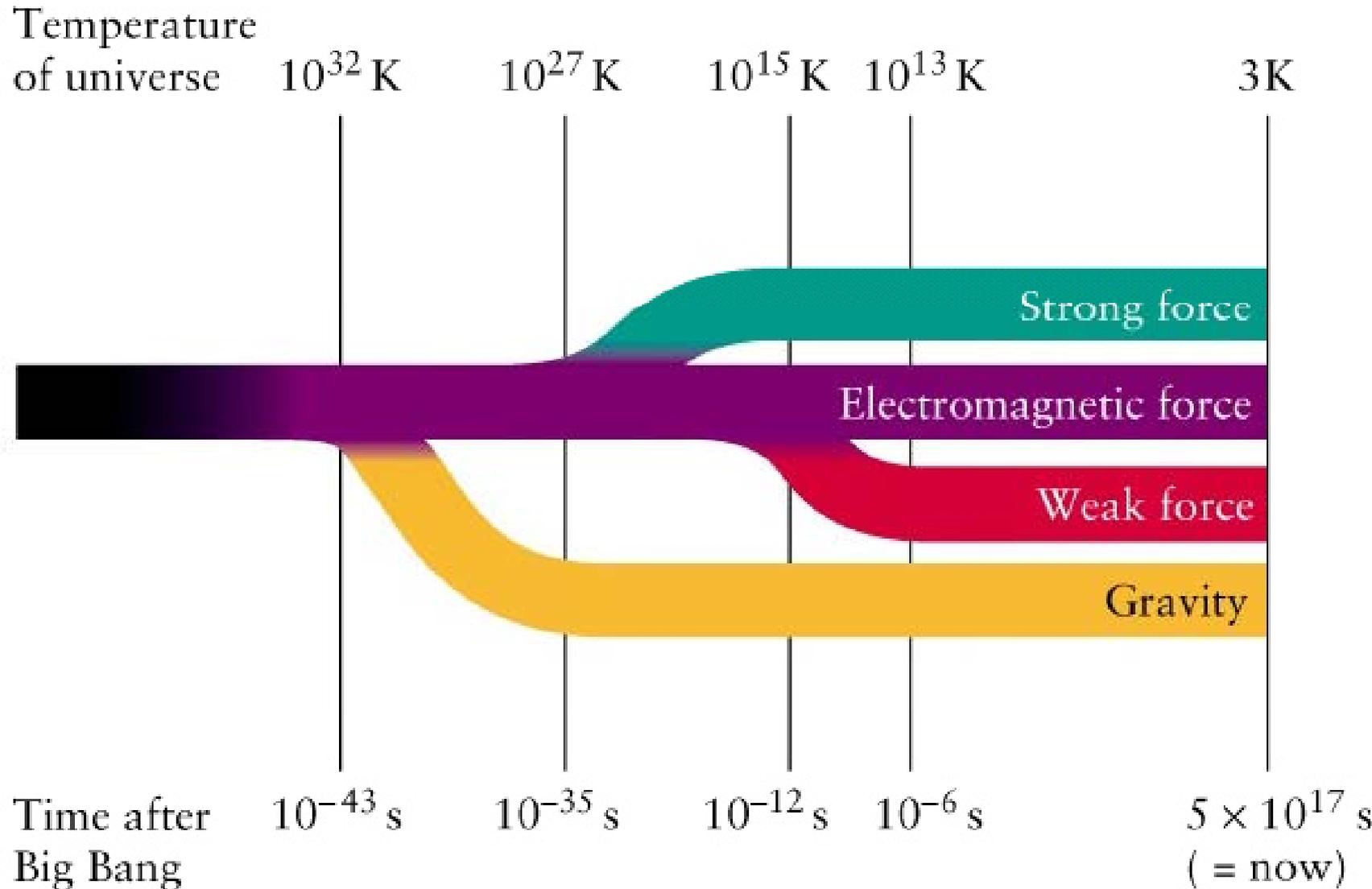
Feynman Diagrams of Weak Interaction



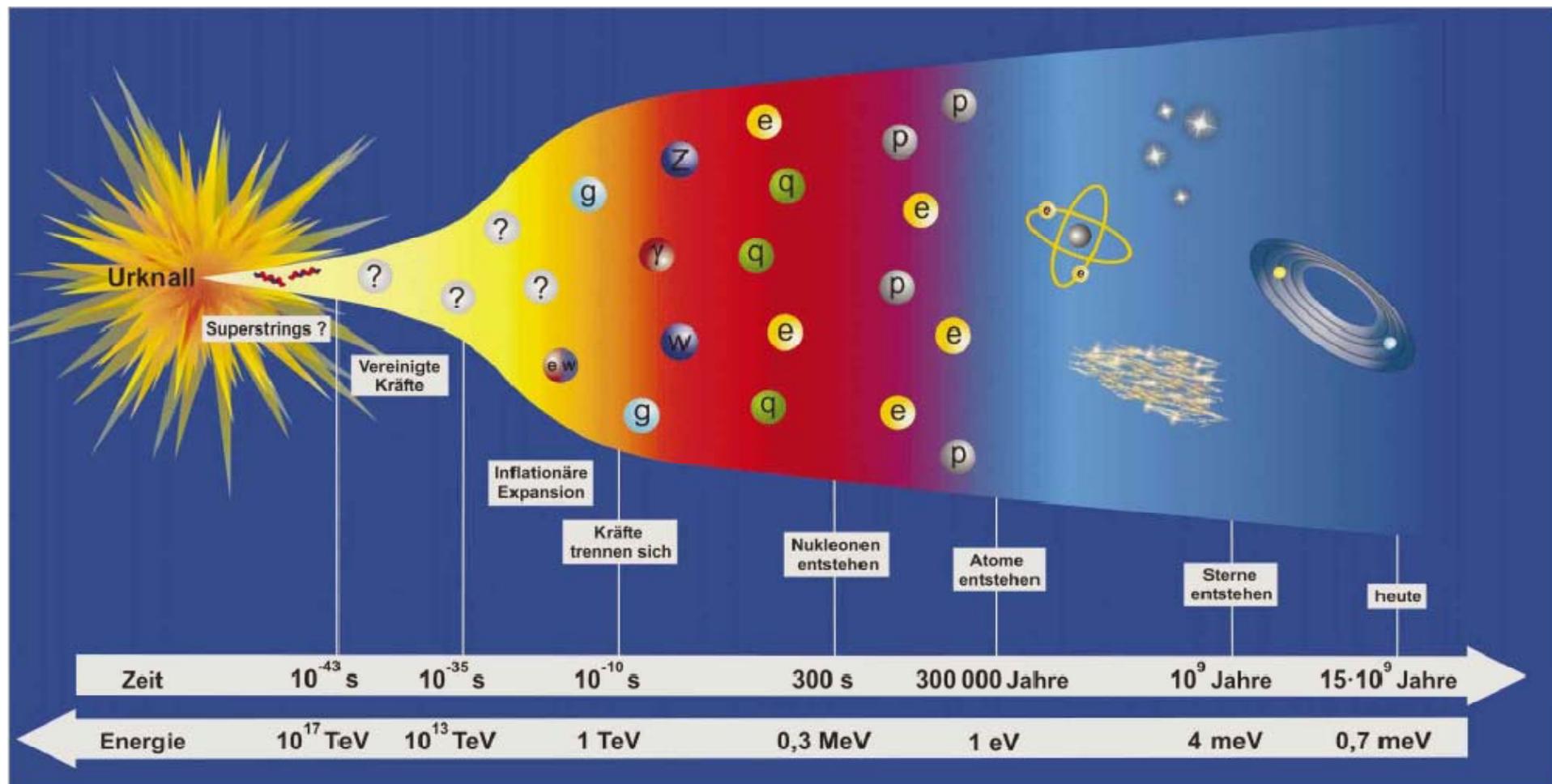
Unification of Forces



Unification of forces and History of Universe



Evolution of the Universe



Energy Content of the Universe

