

Relativistic Quantum Field Theories

Free Theories

- Free scalars
- Free spinors
- Free vectors

...

The “particles”: All enumerated representations of the Lorentz group.

Interacting Theories

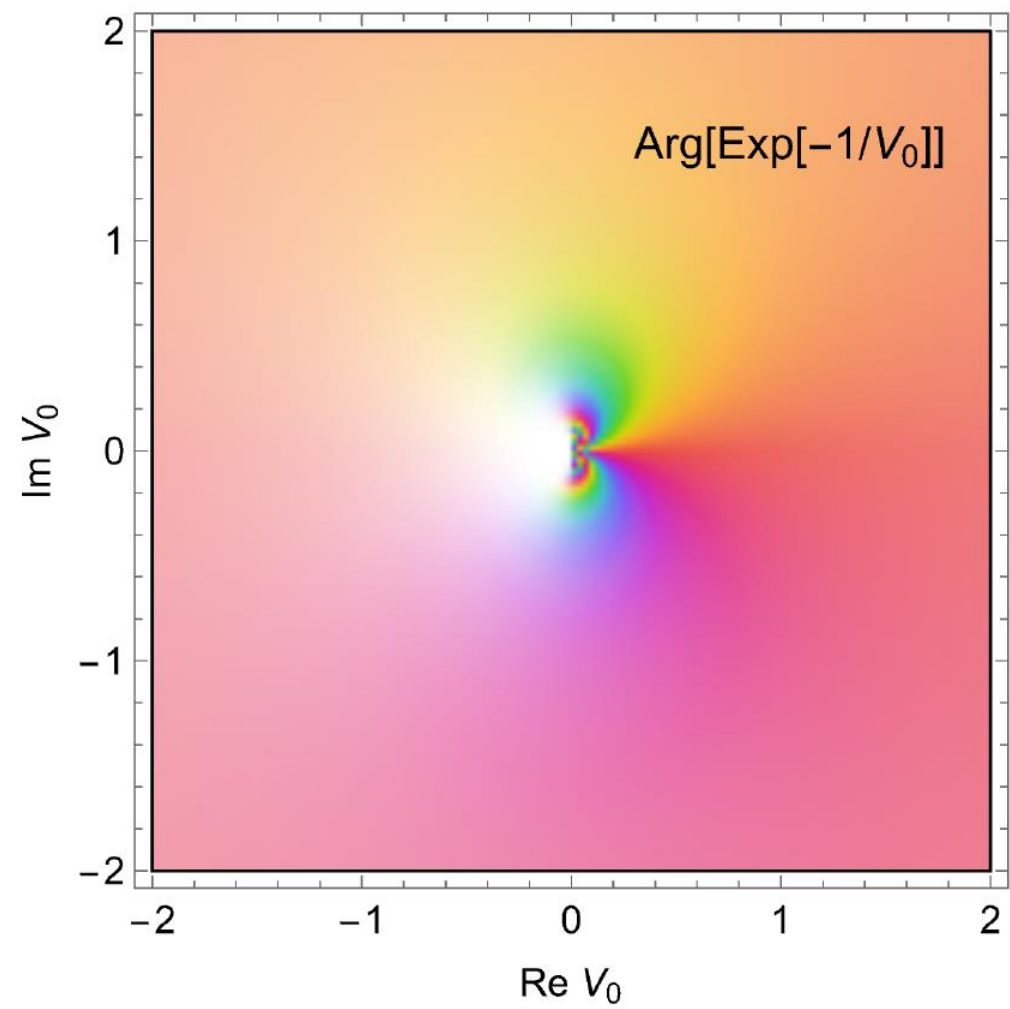
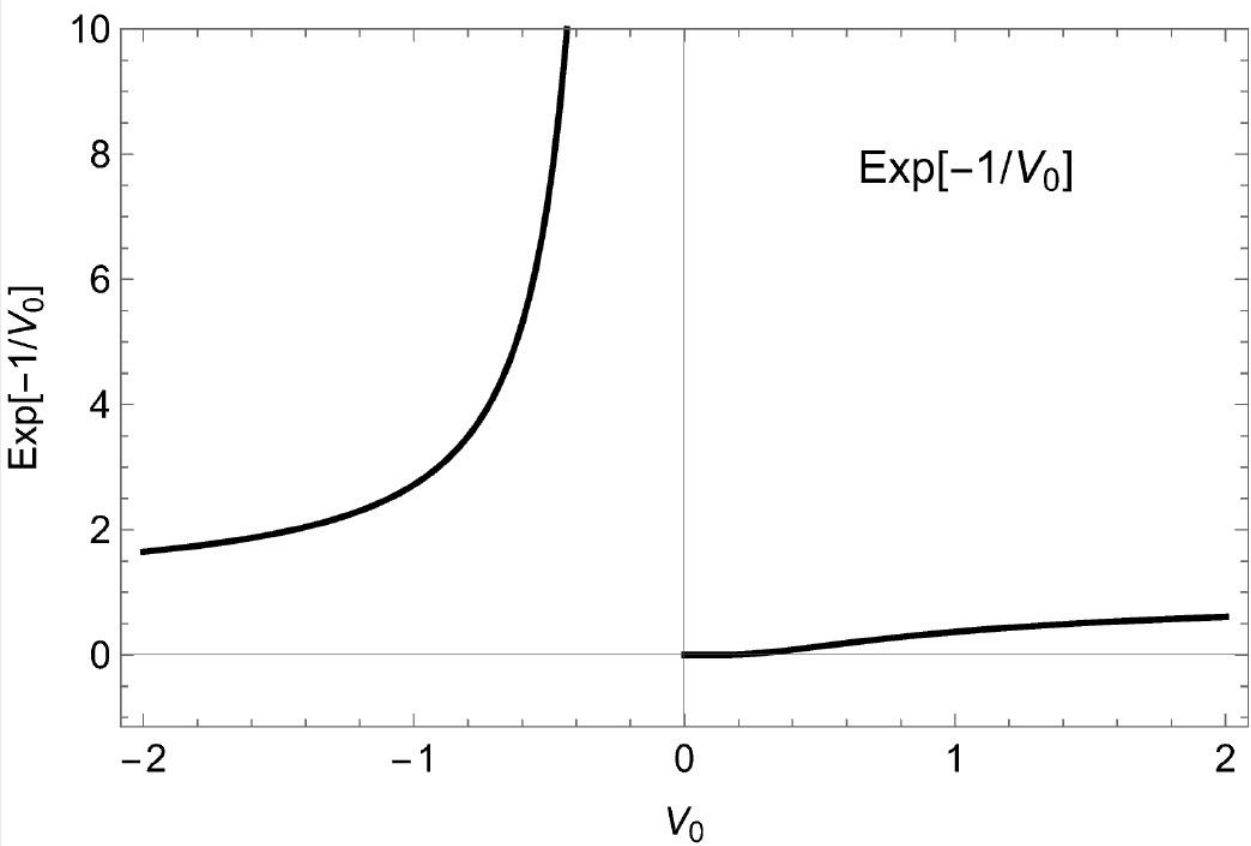
- ϕ^3, ϕ^4 theories
- Yukawa theory

Gauge Theories

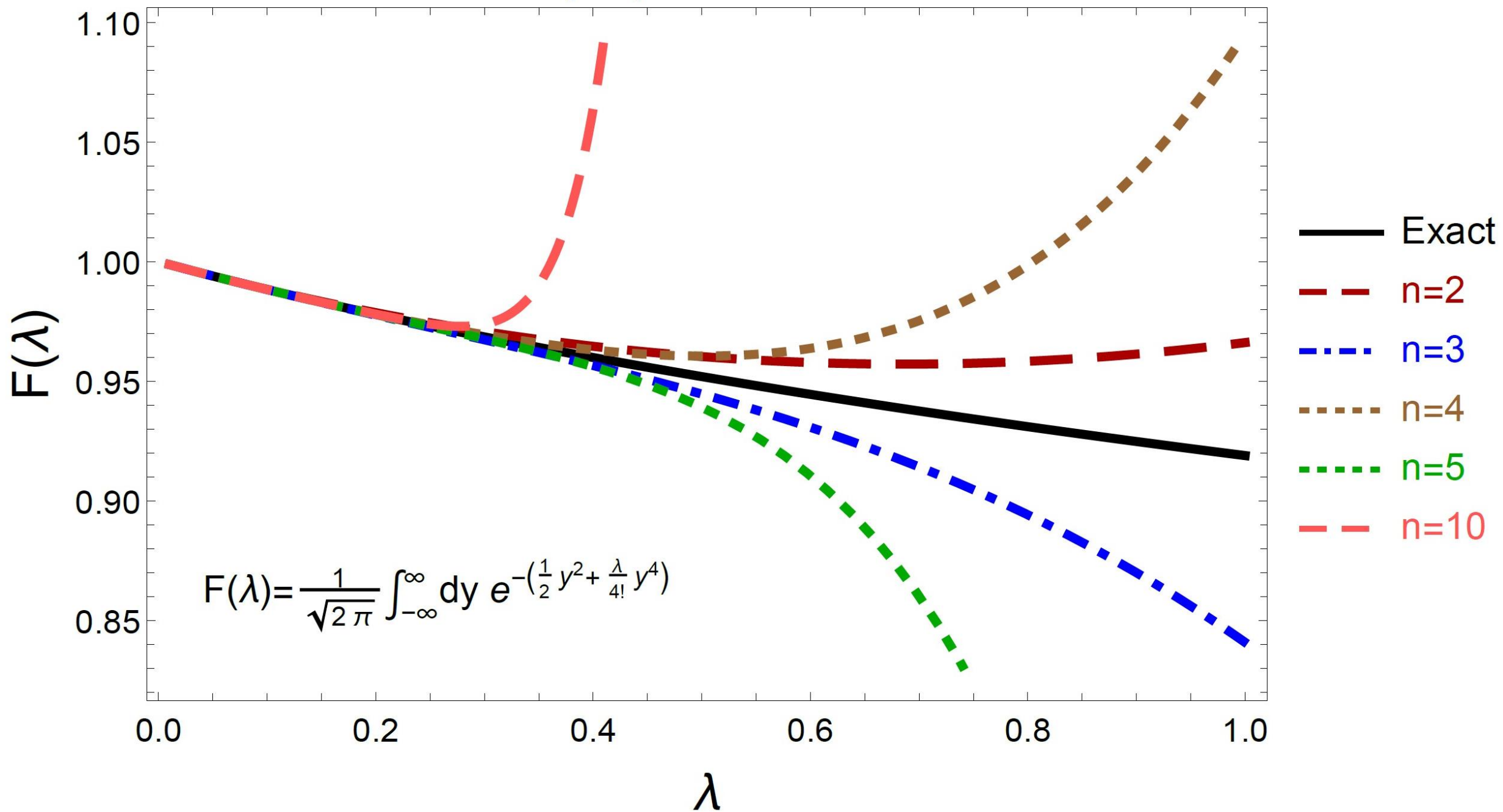
$U(1): QED$

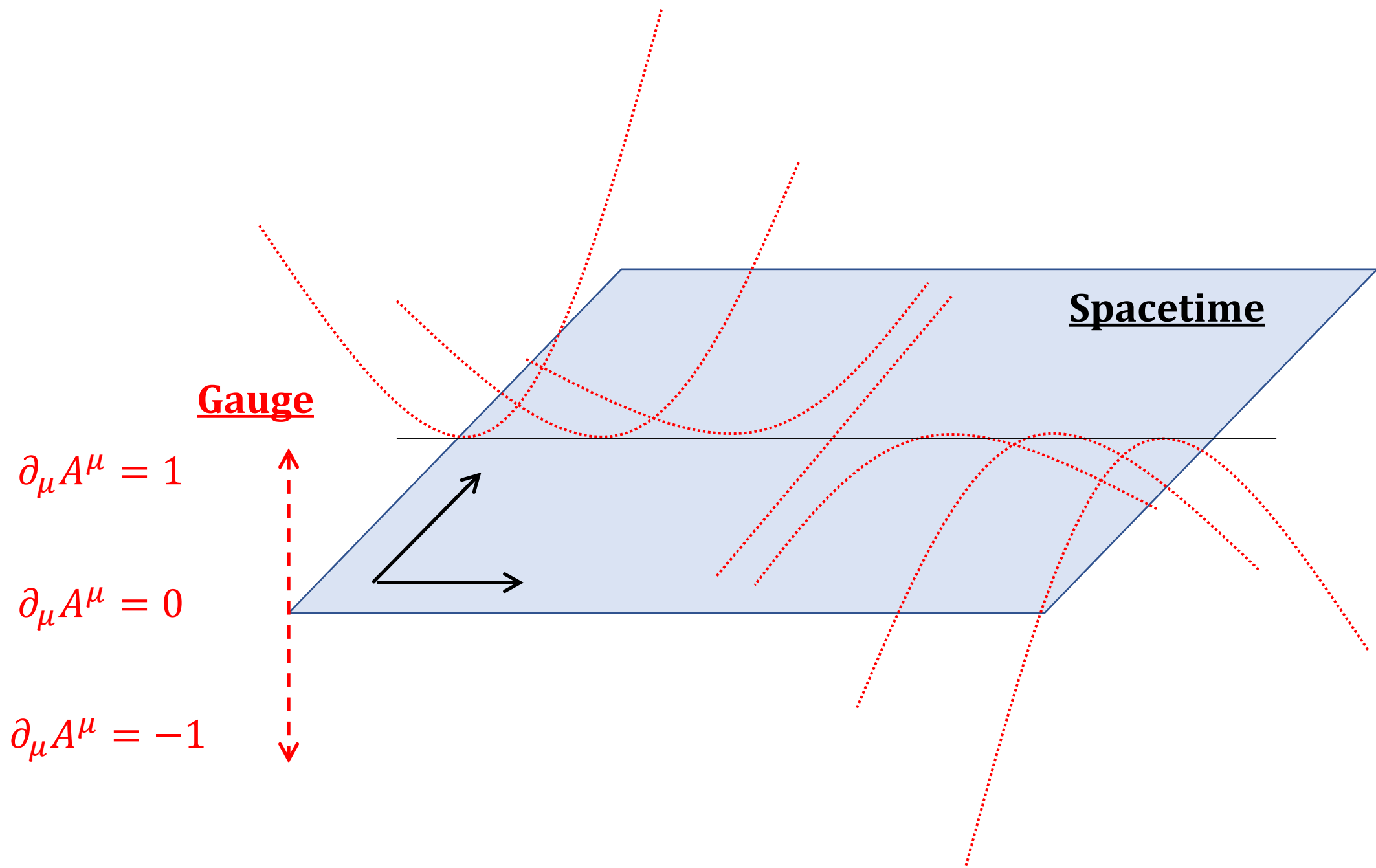
$\star SU(3): QCD$

You are here

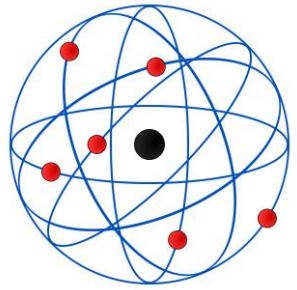


Asymptotic Series





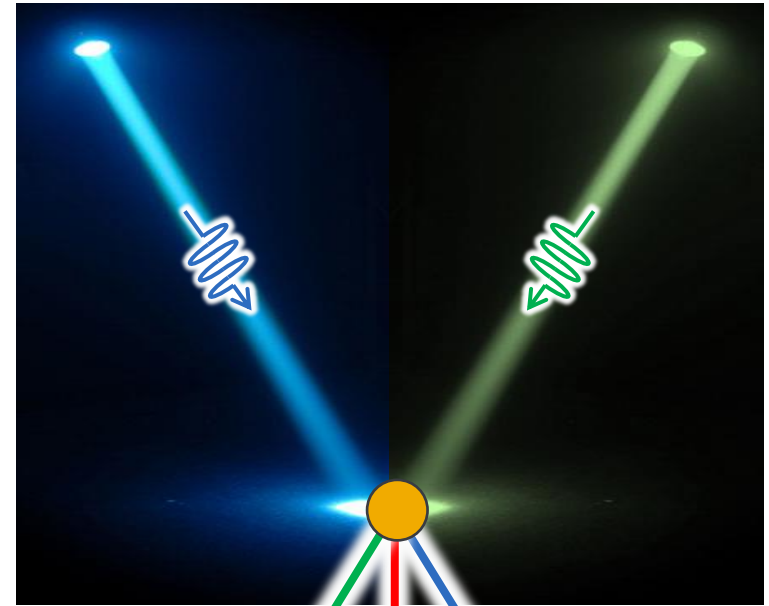
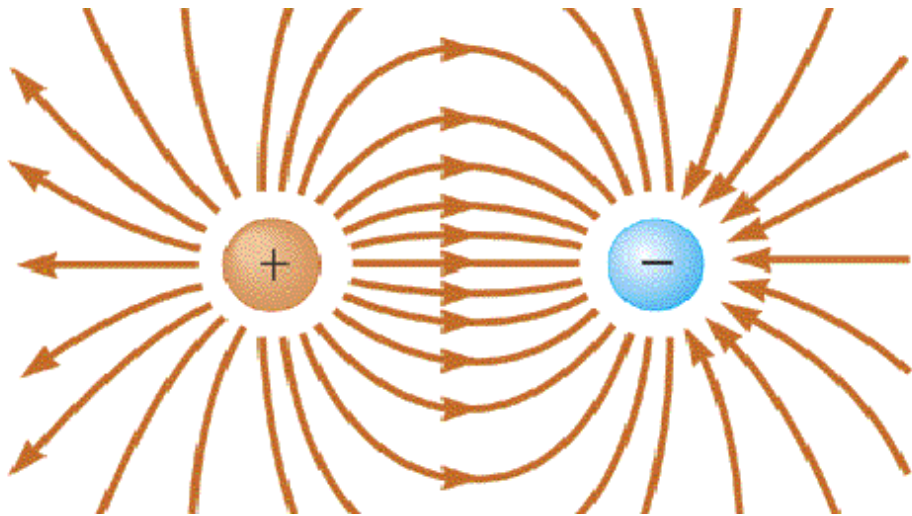
Electro-Dynamics: Charges + Fields



Atom: Electrodynamics

electrons

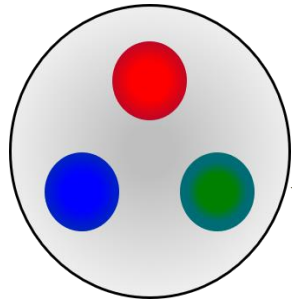
- **Charges** (electrons) radiate **fields** (photons)
- Electric charge is a **scalar** (+/-)



Linear:
Superposition
Principle

$$\vec{E}_1 + \vec{E}_2$$

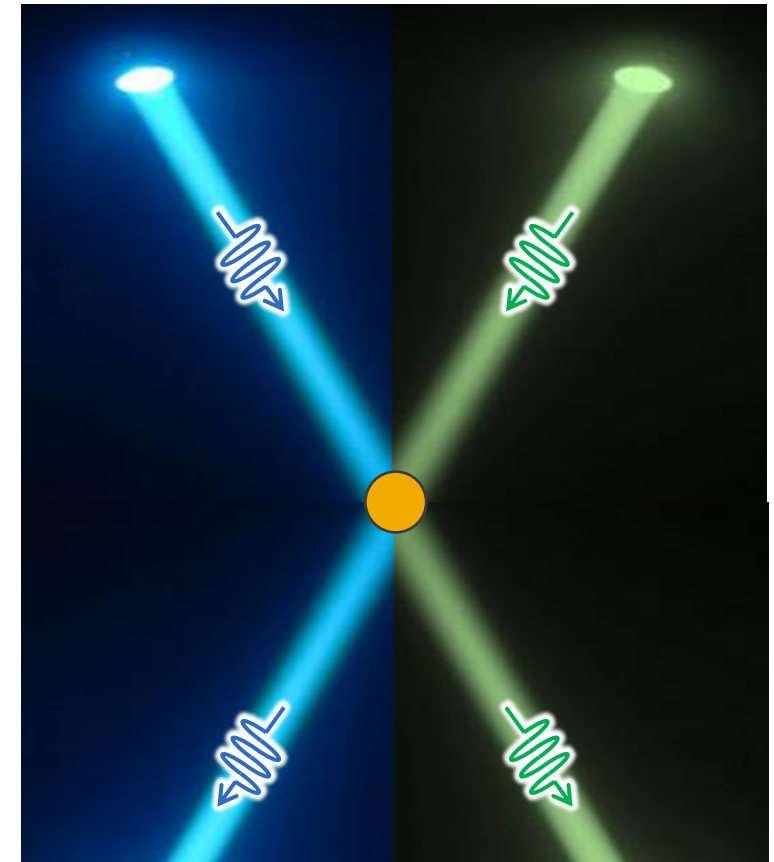
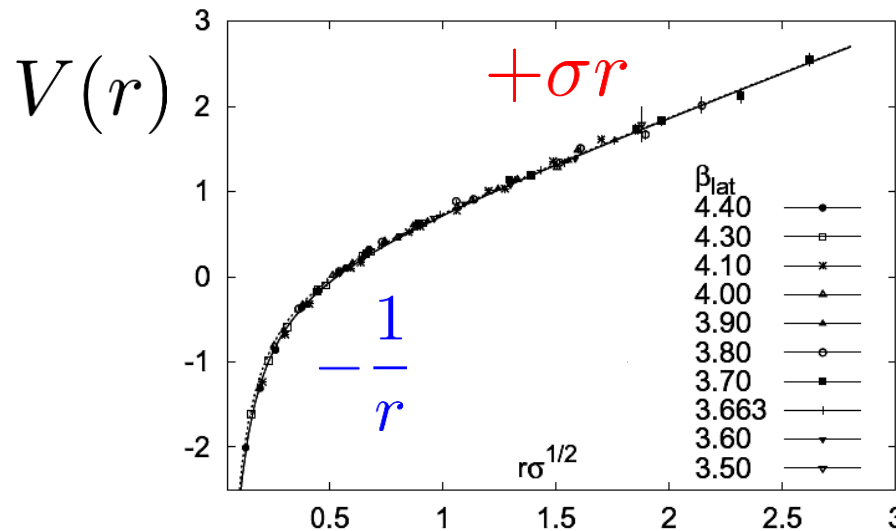
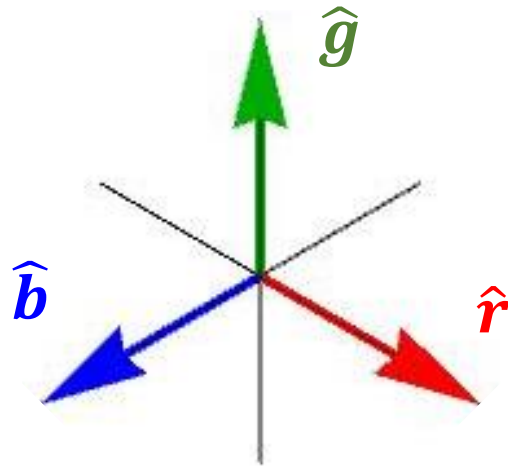
Chromo-Dynamics: One Crucial Difference



Proton: Chromodynamics

“quarks”

- Charges (quarks) radiate **fields** (gluons)
- Color charge is a **vector**



Non-Linear:
Self-interactions of fields

Gell-Mann Matrices

SU(Nc) generators:

$$t^a = \frac{1}{2} \lambda^a$$

$$\lambda^1 = \begin{bmatrix} & 1 \\ 1 & \end{bmatrix}$$

$$\lambda^2 = \begin{bmatrix} & -i \\ i & \end{bmatrix}$$

$$\lambda^3 = \begin{bmatrix} 1 & \\ & -1 \end{bmatrix}$$

$$\lambda^4 = \begin{bmatrix} & 1 \\ 1 & \end{bmatrix}$$

$$\lambda^5 = \begin{bmatrix} & -i \\ i & \end{bmatrix}$$

$$\lambda^6 = \begin{bmatrix} & 1 \\ 1 & 1 \end{bmatrix}$$

$$\lambda^7 = \begin{bmatrix} & -i \\ i & \end{bmatrix}$$

$$\lambda^8 = \frac{1}{\sqrt{3}} \begin{bmatrix} 1 & & \\ & 1 & \\ & & -2 \end{bmatrix}$$

.

(2.13)

Structure Constants of SU(3)

Definition:

$$[t^a, t^b] = i f^{abc} t^c$$

$$f^{abc} = -f^{bac} = -f^{acb}$$

| f^{abc} | 1 | $\frac{1}{2}$ | $-\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $\frac{1}{2}$ | $-\frac{1}{2}$ | $\frac{\sqrt{3}}{2}$ | $\frac{\sqrt{3}}{2}$ |
|-----------|---|---------------|----------------|---------------|---------------|---------------|----------------|----------------------|----------------------|
| a | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 6 |
| b | 2 | 4 | 5 | 4 | 5 | 4 | 6 | 5 | 7 |
| c | 3 | 7 | 6 | 6 | 7 | 5 | 7 | 8 | 8 |