

Particle Physics: Introduction

José I. Crespo-Anadón

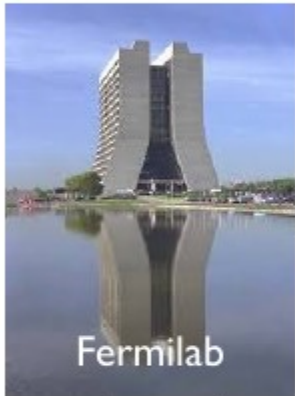
Week 1: September 16, 2017
Columbia University Science Honors Program



Welcome!

José Crespo-Anadón

- Postdoc on Neutrino group, MicroBooNE experiment at Fermilab



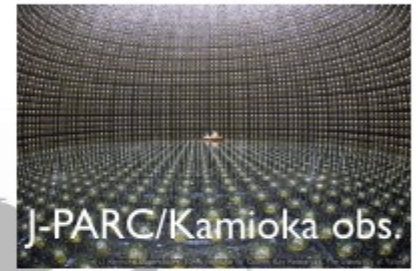
Inês Ochoa

- Postdoc on ATLAS experiment at CERN



Cris Vilela

- Postdoc on T2K and Super-K experiments in Japan



Course policies

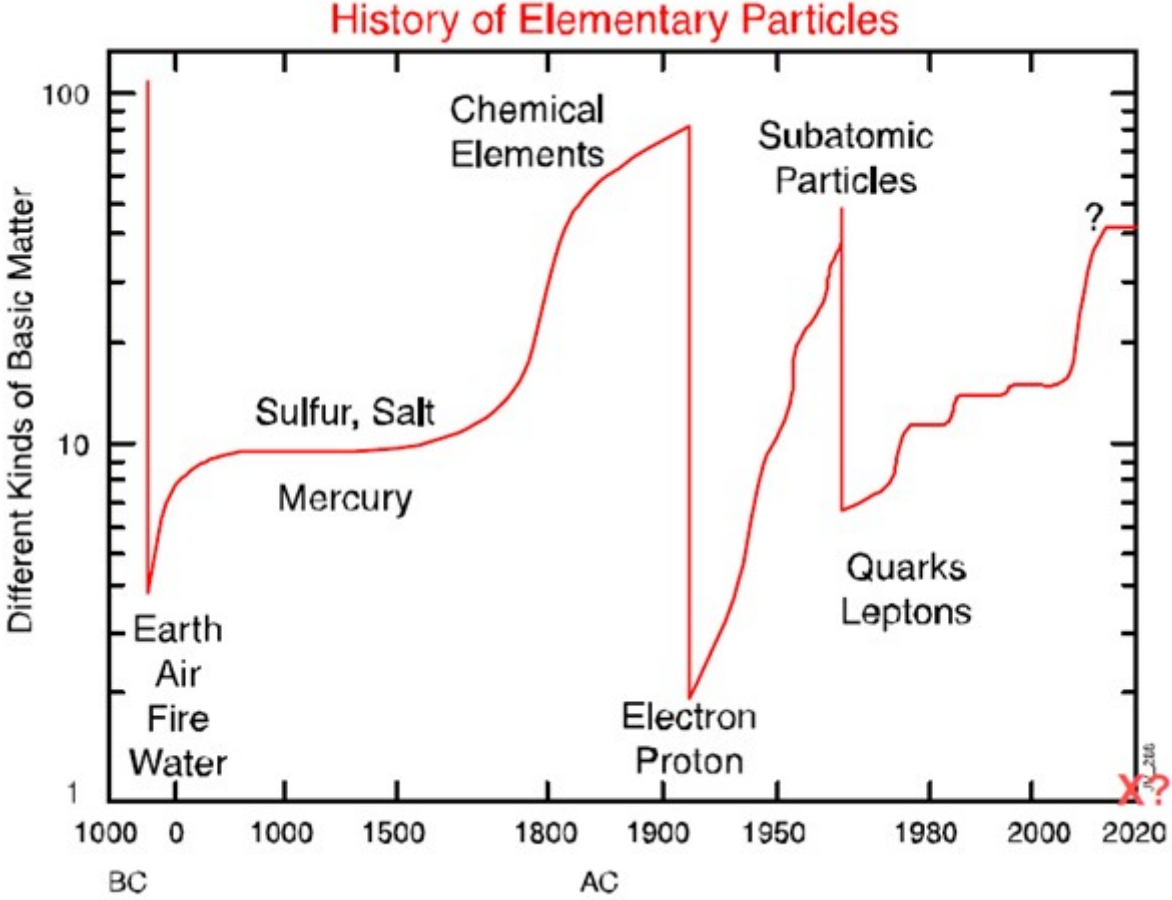
- **Attendance record counts**
 - Up to four absences
 - Lateness or leaving early counts as half-absence
 - Send email notifications of all absences to shpattendance@columbia.edu.
- Please, no cell phones during class
- **Please, ask questions!**
- Lecture materials

<https://twiki.nevis.columbia.edu/twiki/bin/view/Main/ScienceHonorsProgram>

Schedule

Month	Day	Lecture	Teacher
September	16	Introduction	José
	23	History of Particle Physics	José
	30	No classes -- Yom Kippur	-
October	7	Special Relativity	Inês
	14	Quantum Mechanics	Inês
	21	Experimental Methods	Cris
	28	The Standard Model - Overview	Cris
November	4	The Standard Model - Limitations	Cris
	11	Neutrino Theory	José
	18	Neutrino Experiment	José
	25	No classes -- Thanksgiving	-
December	2	LHC and Experiments	Inês
	9	The Higgs Boson and Beyond	Inês
	16	Particle Cosmology	Cris

Evolution of the number of elementary particles



The Final Periodic Table?

	mass → ≈2.3 MeV/c ²	≈1.275 GeV/c ²	≈173.07 GeV/c ²	0	≈126 GeV/c ²
charge → spin →	2/3 1/2	2/3 1/2	2/3 1/2	0 1	0 0
	u up	c charm	t top	g gluon	H Higgs boson
QUARKS	≈4.8 MeV/c ² -1/3 1/2	≈95 MeV/c ² -1/3 1/2	≈4.18 GeV/c ² -1/3 1/2	0 0 1	γ photon
	d down	s strange	b bottom		
	0.511 MeV/c ² -1 1/2	105.7 MeV/c ² -1 1/2	1.777 GeV/c ² -1 1/2	0 1	Z Z boson
LEPTONS	e electron	μ muon	τ tau		
	<2.2 eV/c ² 0 1/2	<0.17 MeV/c ² 0 1/2	<15.5 MeV/c ² 0 1/2	±1 1	W W boson
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino		GAUGE BOSONS

Quiz

- Draw lines between the fermions and the bosons that can interact with them

Charged leptons

Neutrinos

Quarks

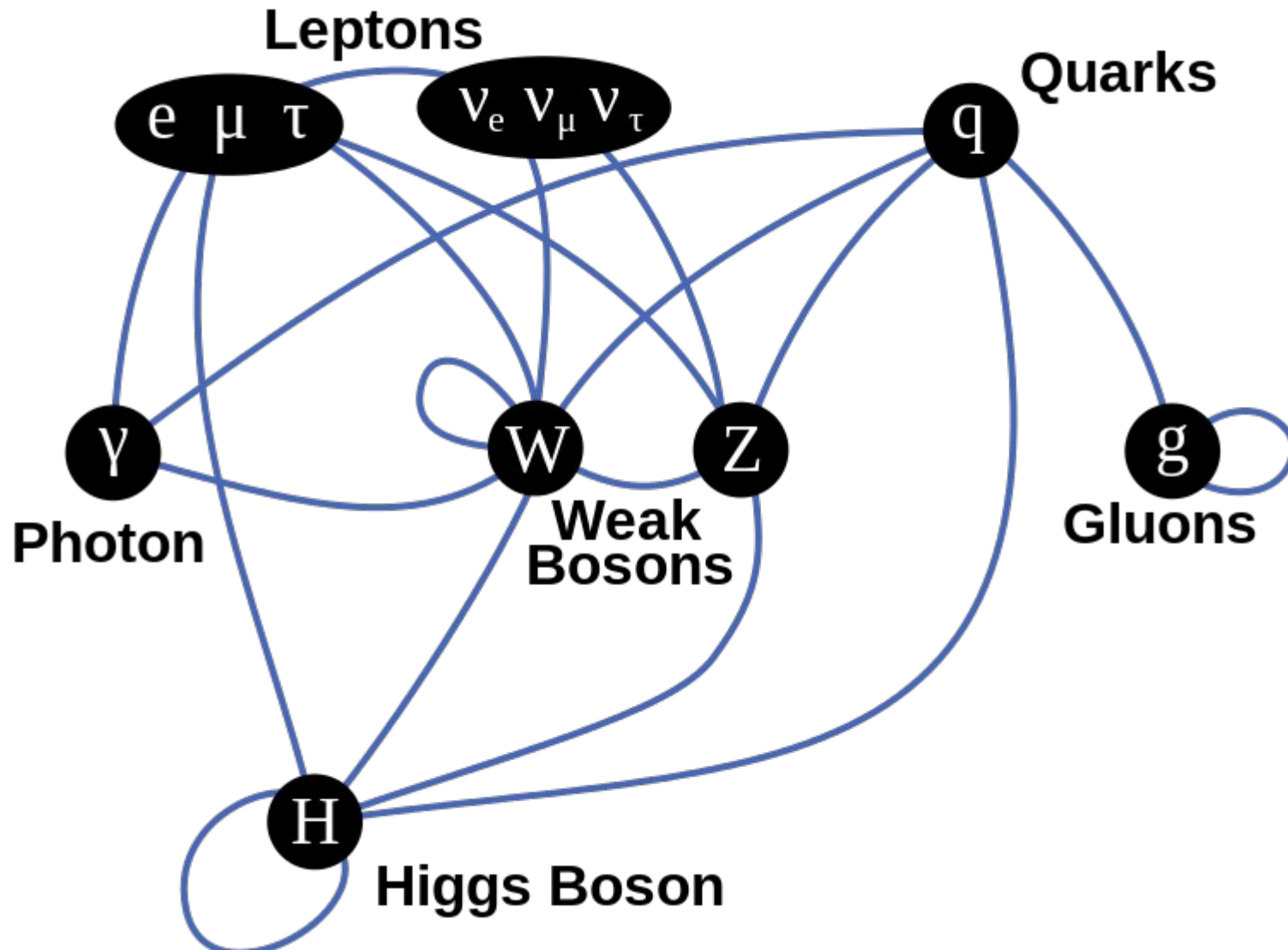
Photon

Weak bosons

Gluon

Higgs Boson

Standard Model solution

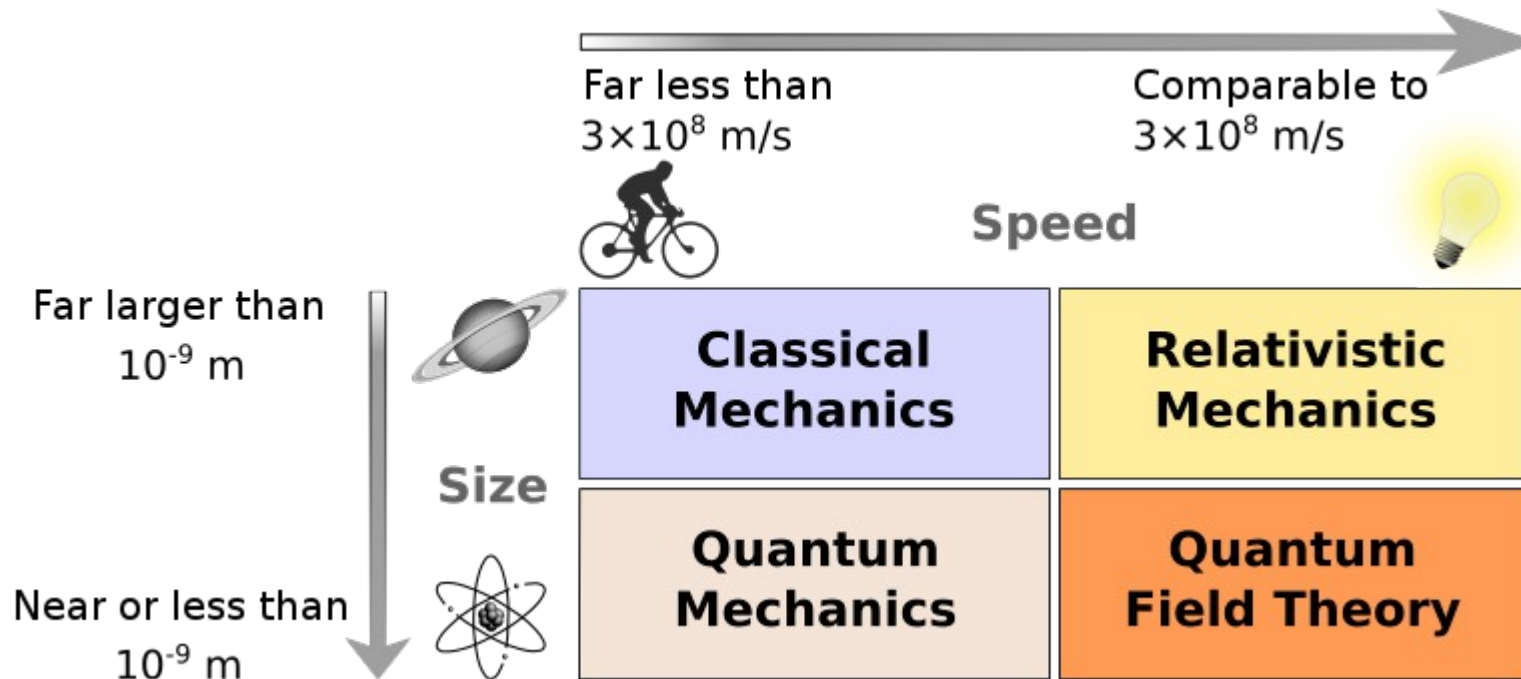


By en:User:TriTertButoxy, User:Stannered - en:Image:Interactions.png, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=3496370>

Powers of Ten (1977)

<https://www.youtube.com/watch?v=0fKBhvDjuy0>

Quantum Field Theory



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