Syllabus (tentative)

PHY249: special topics in plasma physics (also remotely connected as [possibly UCLA PHY250, UCSD PHY239], UCI #48510)

Plasma Accelerator Physics

(Fall Quarter 2021: TTh 12:30-2:00pm , UCI FRHall 4179
also connected by Zoom: personal ID number 743-986-9093:
https://zoom.us/j/7439869093
[contact Assistant: Greg Huxtable huxtablg@uci.edu])

Instructor: Professor Toshiki Tajima
Norman Rostoker Chair Professor, UCI
(Reines Hall 4164; ttajima@uci.edu)

I will connect laser accelerators with other fundamental fields of physics here. First to plasma physics. Then to accelerator physics and high energy physics. Then to laser physics (such as CPA, CAN). We also discuss its impact on laser cancer therapy. Finally we connect recent impact of WFA in high energy astrophysics and multi-messenger astrophysics.

I. Introduction
- Collective acceleration
- Why plasma is unstable? How can plasma be not unstable?

II. Strong banging
- intense lasers, intense beams
- progress of laser intensity---CPA revolution (1985, Mourou* et al.)
- introduction to laser matter interaction and nonlinear optics
- atomic cohesion (quantum coherence), plasma amorphousness, and beyond
- high field---breaks matter, yet can create order
- relativistic coherence
- relativistic optics

III. Wakefield Acceleration
- Veksler-Rostoker problem (1956-1970's)
- What are wakefields? Why are they so stable? Comparison with tsunami
- Tajima-Dawson theory and relativistic coherence
- LWFA (laser wakefield acceleration, 1979, UCLA)
- High Density LWFA
- LWFA-driven nuclear physics
- Laser Acceleration of Ions
- CAN (coherent amplification network) laser (2013, Mourou* et al.)
- ultrahigh energy accelerator with WFA
- ultrafast medical laser surgery, laser-driven beam therapy of cancer

IV. Astrophysical plasma acceleration

Astrophysical jets and disks: coherent structures and engines in nature
EHECR (extreme high energy cosmic rays) and neutrino astrophysics (again UC Irvine's forte)
ZeV neutrino physics and TeV gamma astrophysics
gravitational waves (LIGO by Barry Barish **) and gamma bursts from neutron star collision

Overall reference:
T. Tajima, X. Q. Yan, and T. Ebisuzaki, Rev. Mod. Plas. Phys.**4**, 7 (2021).
Refs. (additional):
G. Mourou*, T. Tajima, and S. Bulanov, Rev. Mod. Phys. **78,**309 (2006).
T. Tajima, K. Mima, and H. Baldis, eds. *High Field Science* (Kluwer/Plenum, NY, 2000).
(More to come)

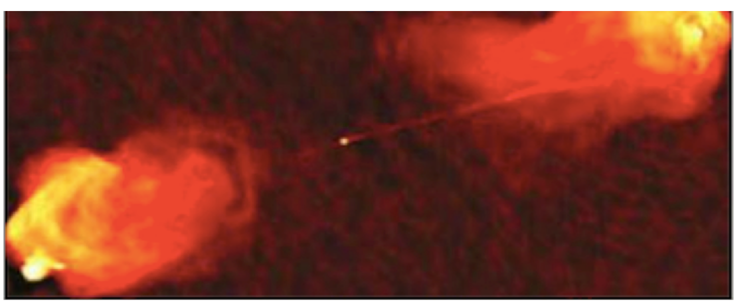
Assignments:
To be discussed in the class: HW: 20%; Proposal for the term project: 20%; Term Report: 60%.

**) 2017 Nobel Laureate in Physics.
*) 2018 Nobel Laureate in Physics.
examples of the term projects in UCI _PHY249 (Winter 2014; Winter 2019):

C. Lau, P. C. Yeh, O. Luk, J. McClenaghan, T. Ebisuzaki, and T. Tajima, Phys. Rev. STAB **18**, 024401 (2015).

B.S. Nicks, S. Hakimi, E. Barraza-Valdez, K.D. Chestnut, G.H. DeGrandchamp, K.R. Gage, et al., Photonics **8**, 216 (2021).

In the Term Report, in addition to your term project work description, you have to identify what the instructor indicated as to how and why we can avoid plasma instabilities in wakefields, or alternatively you have to discover new mechanism for stability.



(NRAO/AUI)