Syllabus

PHY249: special topics in plasma physics

High Field Science

(Winter Quarter 2014: Tues & Thurs 9:30am-10:50am)

Instructor: Professor Toshiki Tajima
(Frederick Reines Hall 2111; ttajima@uci.edu)

I. Introduction
- progress of laser intensity---CPA revolution
- 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

II. Wakefield Acceleration
- Veksler-Rostoker problem
- ponderomotive force
- Tajima-Dawson theory and relativistic coherence
- LWFA (laser wakefield acceleration)
- Compact X-ray sources
- PeV physics
- laser-driven collider and Higgs' factory

III. Laser Acceleration of Ions
- Mako-Tajima problem
- TNSA (target normal sheath acceleration)
- RPA (radiation pressure acceleration)
- relativistic protons
- applications---nuclear, medical, mechanical, pharmaceutical, etc.

IV. Vacuum Nonlinearities
- What nonlinearity optics teaches us
- Euler-Heisenberg Lagrangean
- Schwinger field
- Dark Matter and Dark Energy
- Degenerate four wave mixing (DFWM) method and laser collider for dark fields
- laser detection of relic neutrinos

V. Ultimate technologies
- CAN (coherent amplification network) laser
- collective decelerators, plasma compressors, plasma mirrors
- laser driven compact XFEL (X-ray free electron laser)
- laser driven compact gamma ray sources
- laser driven ADS (accelerator driven systems)

VI. Astrophysical Acceleration
- Fermi acceleration and its limit
- AGN (active galactic nuclei) accretion disks and jets
- relativistic coherence in superrelativistic Alfven waves
- ponderomotive acceleration to ZeV
- EHECR (extreme high energy cosmic rays) and astrophysics
- ZeV neutrino physics and TeV gamma astrophysics