

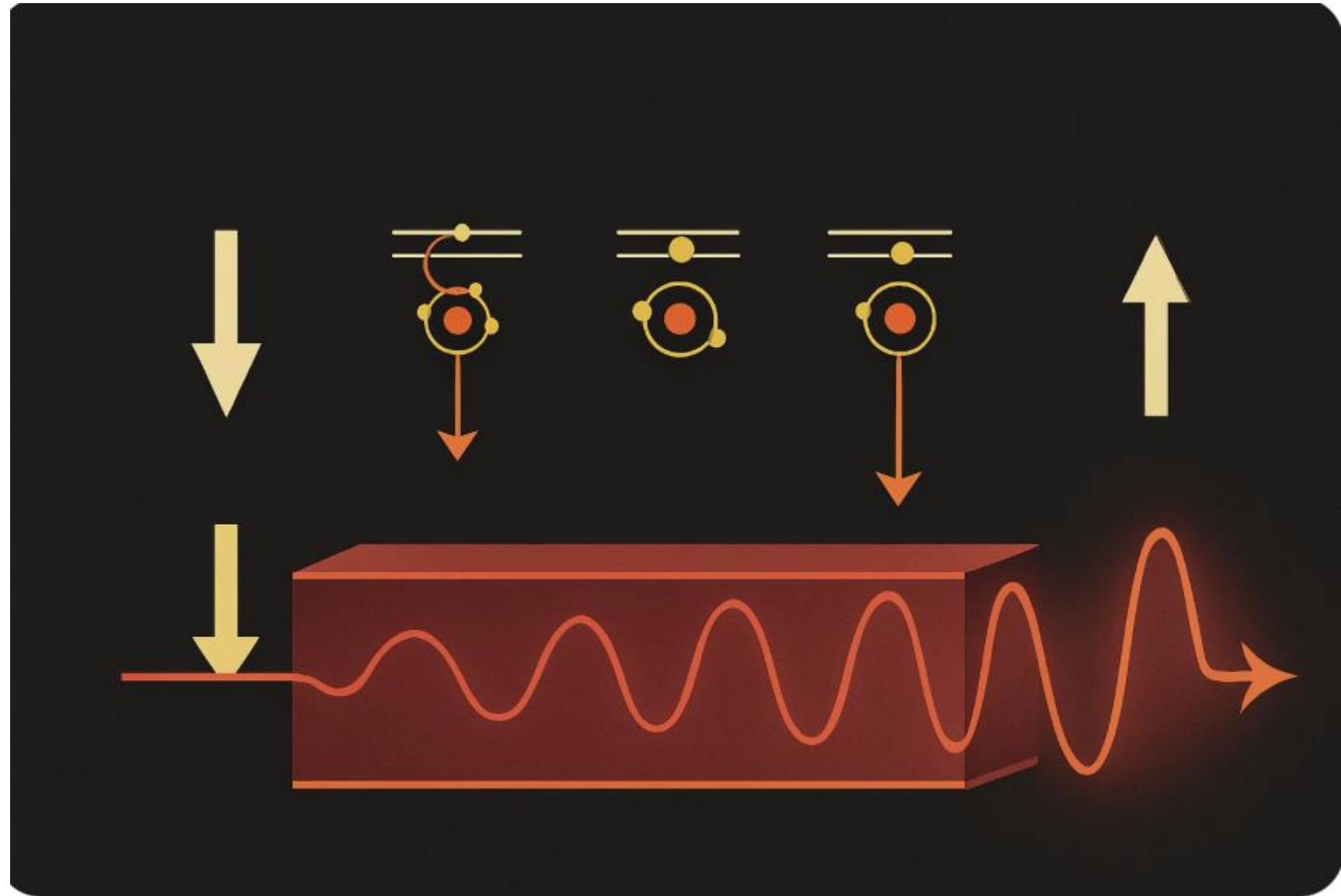
Welcome to

MLL 253

Electrical,
Optical and
Magnetic Properties
of Materials

2026-2027 Odd Semester

3 – 0 – 0



Instructor

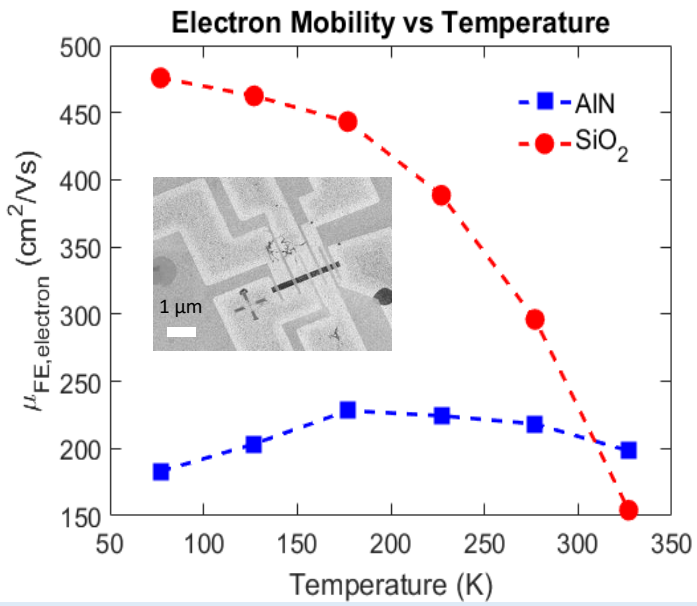
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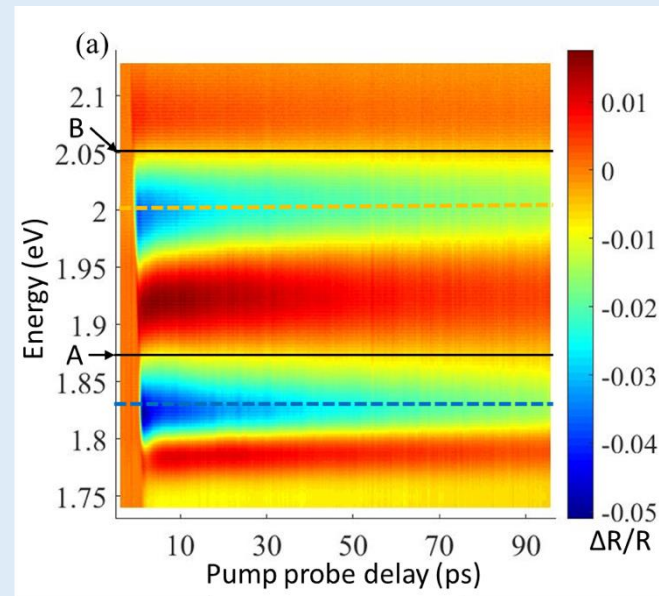
Teaching Assistants: (1)

Apurva Yadav

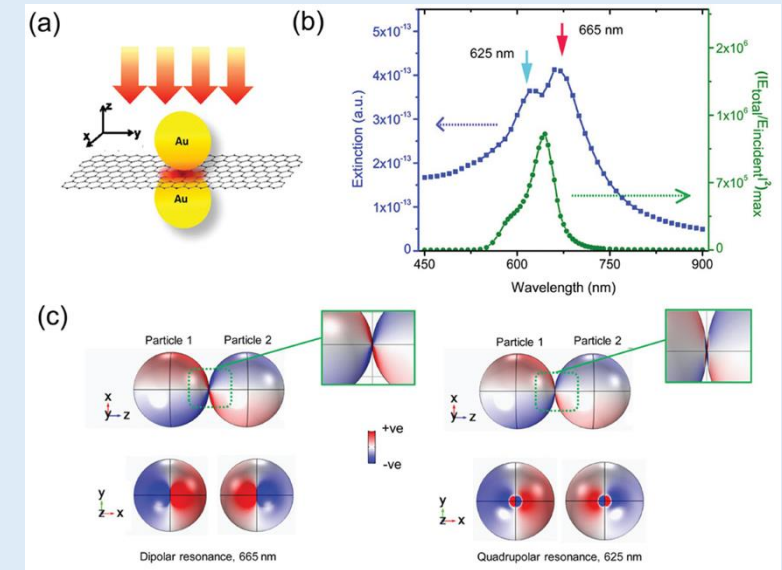
Graphene on III-V substrates



Ultra-fast dark exciton dynamics – TMD MoS₂

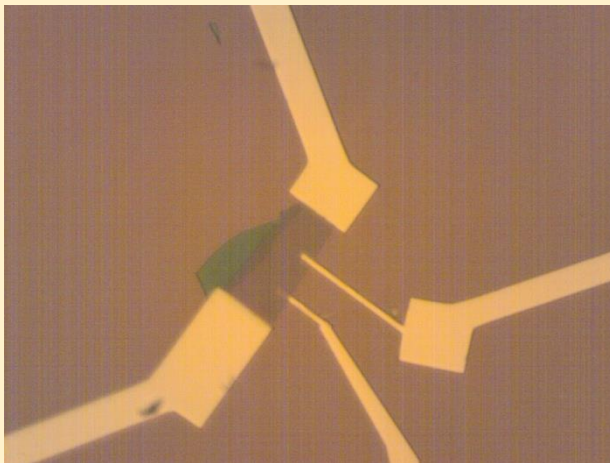


2D-nanoparticle plasmonics

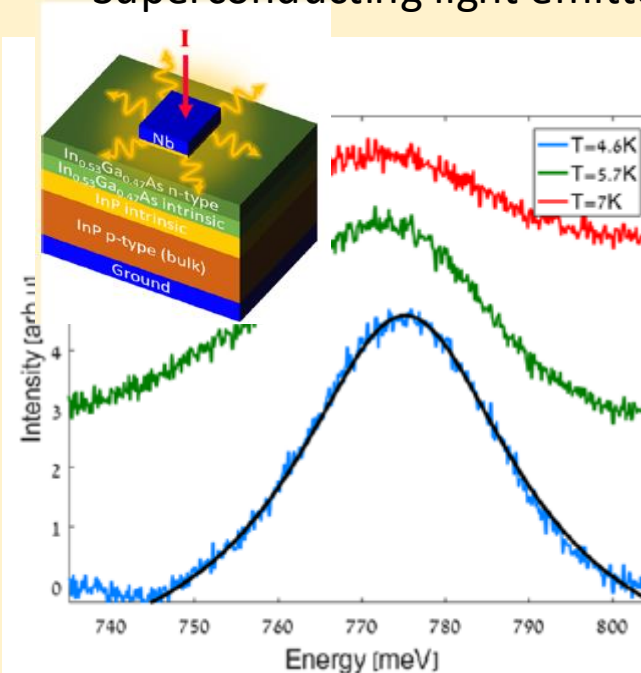


2D Electron transport
and optics

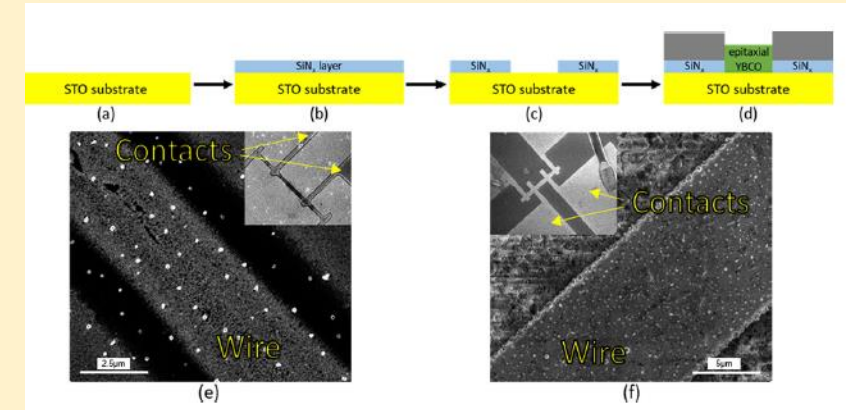
2D – Superconductor interfaces



Superconducting light emitters



Superconducting nanowire photon detector



Superconductivity

Nature communications 10 (1), 1-9
 Optics Express 27 (23), 33427-33435
 physica status solidi (a) 217 (16), 1900949
 Journal of Physics D: Applied Physics 49 (26), 265301
 Nanotechnology 27 (20)

About the course

- First Step into Electrical/Electronic Materials
- We will deal with
 - Electronic properties
 - Dielectric properties
 - Optical properties
 - Magnetic properties

Content

MLL253 Electronic, Optical and Magnetic Properties of Materials

3 Credits (3-0-0)

Pre-requisite(s): PYL100

Overlaps with: PYL102, PYL703, CML102

Electronic Properties: Classical conductivity, Quantum description of conductivity, Effect of alloying in metals, Intrinsic & extrinsic semiconductor properties, Application of Fermi-Dirac statistics, Fermi level & Hall effect, Two probe and four probe measurements, Conductive polymers, Ionic conductors, Superconductors, Device applications (Diode, Ohmic/Schottky junctions etc.).

Dielectric properties: Dielectric constant, Maxwell's equations, Complex dielectric constant, frequency dependence, Non-linear dielectrics, Chemical synthesis routes.

Optical properties: Beer-Lambert's law, Transmittance, reflectivity & conductivity, Classical & quantum approach to optical properties, Phonons, Spectroscopy, luminescence, fluorescence, Optical devices (LASERs, LEDs).

Magnetic Properties: Types of magnetism (Ferro-, para-, ferri-, dia- and antiferro-), Susceptibility, Curie temperature, Neel's temperature, Domain structure and magnet design; Synthesis of magnetic and superconducting materials.

Week starting with	number of days	Topics
1	1	Introduction
2	3	Electrical and Thermal conduction
3	3	quantum electron
4	3	Band theory
5	3	Semiconductors, devices
6	3	Semiconducting devices
7	3	polarization of materials
8	2	Dielectric constant and others
9	1	Minor
10	3	Piezo, pyro and Ferro
11	0	Semester break
12	3	Refractive Index, absorption and scattering
13	3	Absorption, scattering
14	3	Emission, LED and Lasers
15	3	Magnetization of matter
16	3	Types of magnetism, and transitions
17	3	Superconductivity and others
		Major
	42	

Course Learning Outcomes

After successful completion of the course,

- You will be able to understand from basic principles electronic properties of materials. Distinguish between classical approach and places where quantum conductivity must be employed. Appreciate the beauty in variety of electronic materials.
- You will be able to understand dielectric properties. How to choose these materials for different applications. How to characterize these materials.
- You will be able to explain why some materials are transparent while others are not. You will be able to tell the difference between the quantum and classical properties of materials.

Course Information

Course Timing:

- Lectures
Slot E, Tuesday, Wednesday, and Friday 10 AM – 11 AM

Prerequisites:

- Basic first year Math, Physics – Calculus, Electromagnetics. (PYL100)
- Inquisitiveness to learn!

Lecture Hosting

- Lecture delivery:
 - All sessions in-person at Block IV LT2
 - Attendance will be recorded. In-fact participation in lectures is mandatory.
- Homework to be submitted in moodle. Could involve simple coding exercising.
 - Submissions are binary: either you submit before time or leave without marks. Sorry, no concessions for any amount of delay!
- All exams and evaluation will be offline. The answer sheets will be evaluated by TA assigned.
- Dishonesty will be very seriously dealt with. We are a huge team of very experienced professionals. So, any malpractice will be identified, and the student will be given a 'F'. Remember, this is much worse than just dropping the course!

References

- Multiple references for each topic. Will be announced during the lecture time. General references are as follows:
- R. E. Hummel, Electronic Properties of Materials
- S. O. Kasap, Principles of Electronic Materials and Devices
- S. M. Sze, Semiconductor devices: Physics and Technology
- D. Jiles, Introduction to the electronic properties of materials

Evaluation policy

Evaluation:

- Relatively graded course with the following split up:
35% minor, 40 % major, 15% homework/assignments/quizzes and 10 % in-class interactions, attendance
- All Exams are written, subjective and will require detailed calculations.
- Audit Pass is 35%
- Re-examination only for students having attendance > 75%

Academic Honesty

All students registering to this course voluntarily commit to the academic integrity, research and Ethics policy, IIT Delhi (https://academics.iitd.ac.in/sites/default/files/registration/forms/10_FORM%20H.pdf). This is an under-graduate level course in the country's most premier institute, and I expect the students to know their responsibility. If any document submitted to us is plagiarized (copied verbatim either from textbook/ online resources/ fellow students...), the student will be deregistered and promptly handed to institute authorities.

Discussion is okay for homework, but the submission needs to reflect the student's work. No discussion/references are allowed in lab sheets, quizzes/minors/final exams.