Relativity Based on Symmetry Lecture series

The aim of the series is to introduce ideas of classical and modern physics to people with a mathematics background and interested in physics. We show how the symmetry of the laws of Nature, expressed by an appropriate mathematical model, leads to Special and General Relativity and some parts of Quantum Mechanics. Applying mathematical knowledge to real-life problems may stimulate mathematical research toward a deeper understanding of reality.

Keywords:  Relativity and symmetry, Unification of physics, Simple relativistic gravitation, Meaning of wave function, Electromagnetism and spin-half, Relativity principle, Representations of relativity principle, Tensors as a language of nature, Precession of planetary motion

The lectures started on April 29, 2020

Lecture 1: OVERVIEW OF PHYSICS. Presents the need for modification of Classical Physics and how Relativity and Quantum Mechanics provide such modification. The role of symmetry in physics

Recording link: <https://drive.google.com/file/d/1sZnGWaddflbO302QBHZSUTtzH5t3_dWR/view?ts=5ebacb4f>

PPT: <https://drive.google.com/file/d/1gUuyIJV-F60h3x1jaBZOw3piJkYSkkCB/view?usp=sharing>

Lecture 2: CLASSICAL MECHANICS The Principle of Relativity, Galilean Transformations and Newton’s laws, Gravitational and electric fields, Motion of a planet and binary stars.

Recording:

<https://drive.google.com/file/d/1KqG0U9G63VwarVif7AUvWCwBFQGyRiYd/view?ts=5ebd2f13>

PPT:

<https://drive.google.com/file/d/1mkJ6lEj70Pm2kG9LbVoLLLPeYyWRnesp/view?usp=sharing>

Lecture 3. TENSORS AS A MATHEMATICAL LANGUAGE OF PHYSICS Motivation for use of tensors, Einstein's summation convention, Vectors, co-vectors, matrices and metrics, Levi-Civita symbol, Vector analysis in 3D

Recording:

<https://drive.google.com/file/d/14idmFKj28GVhpgJtVzZRsUi3lJcDM9tZ/view?usp=sharing>

PPT:

<https://drive.google.com/file/d/163uBsCSDfZIySTEBaET83KRGQXekQg2C/view?usp=sharing>

Lecture 4. Variational principle and geodesic motion.

Principle of least action, Euler-Lagrange equations, Generalized Principle of Inertia, Geodesic motion in Relativistic Newtonian Dynamics, Snell's law

Recording

https://drive.google.com/file/d/1xcsiZ7JzrSGCCRPkUdpCmVxB3g6LPGQo/view?usp=sharing

PPT of the lecture

https://drive.google.com/file/d/1h8\_PcU1qY9SVDuayig1-5YTxjz8H48xt/view?usp=sharing

PPT of solutions Homework TPPL 3

https://drive.google.com/file/d/1CQVGhZQk9-Xfqh\_cqAkRkn-jxsMvTep8/view?usp=sharing

Lecture 5. Lorentz transformations,

Lorentz transformations from principle of relativity, Invariant metric, Preserved Speed; Velocity addition, Fizeau experiment; FOF and Sagnac effect

Recording:

<https://drive.google.com/file/d/1UfttxTH7aMhGWL5GzX-0hv2q7hr7lKKG/view?usp=sharing>

PPT<https://drive.google.com/file/d/1NEE85uPTD36dnHOWUAixygvMULRWnY_X/view?usp=sharing>

PPT Homework TPPL 4

<https://drive.google.com/file/d/1ETcoEvKlLcF97xgFVKNQh7RhgjAE0u26/view?usp=sharing>

Lecture 6. Relativity and bounded symmetric domains,

Real bounded symmetric domains; The projective geometry of the admissible velocity ball, Four-velocity and four-acceleration, 4D Relativistic Dynamics Equation

Recording: Part 1

https://drive.google.com/file/d/1PEZvy0B5e\_-rmZjXZXyyMxdKYvCh86mR/view?usp=sharing

Part 2

https://drive.google.com/file/d/1kpwlsk\_90wgS6j4zVzMHueM0LMksRmod/view?usp=sharing

PPT

https://drive.google.com/file/d/1Zrc7K9cCEYHNvit2\_e-3SzTQcRwmaymx/view?usp=sharing

PPT Scarr

https://drive.google.com/file/d/13ONG6jEHOORH8xGSBO6t8V-2w7FKURRW/view?usp=sharing

Lecture 7 Mathematical model for fields propagating with the speed of light

Use of fields to describe action at a distance, Bi-polar coordinates and astronomy observations, Local basis, Lorentz group representation 𝜋\_𝐿, Invariance of 𝜁=𝜃−𝑖𝜑 under 𝜋\_𝐿, Pre-potential

Recording

https://drive.google.com/file/d/1WnAW567INA6IjVPhKtEJuDmkKCdGW-xx/view?usp=sharing

Recording Supplement to TPPL 6

https://drive.google.com/file/d/1MvgIswOpI2Eiql08\_rluqYpEAhejtVHo/view?usp=sharing

PPT

https://drive.google.com/file/d/1uYkqh1pdupPUaU3RE9t703NSKGwO-\_j1/view?usp=sharing

PPT supplement

https://drive.google.com/file/d/17cSxo8B1Mfmm-HwXKbxcV1V-Nbvq7iSf/view?usp=sharing

Lecture 8. Electromagnetic field

Diamond product, Gradient of the relative position vector Bi-polar coordinates, Four-potential of the field, Electromagnetic field tensor, Near and radiation fields, Electromagnetic field from several sources, Maxwell equations, Meaning of complexification

Recording

https://drive.google.com/file/d/1bNtsYP8KasS0HPxLGUupgjTbr11gmXRY/view?usp=sharing

Supplement recording

<https://drive.google.com/file/d/12anqqdH_1k4Dra-ttokqsZXTNLNLW8zP/view?usp=sharing>

PPT lecture

https://drive.google.com/file/d/16e22knZOkGOfa8E3VXh80eZkP8w0OQ1C/view?usp=sharing

PPt supplement

https://drive.google.com/file/d/1WqUP2f0OuZpDg5YA49K0XWyzmNnOmVxb/view?usp=sharing

Lecture 9 Relativistic Gravitation and GR tests. Relativistic Newtonian Dynamics for gravitational field, Derivation of metric of a spherically symmetric body, Gravitational time dilation, Planetary Motion. Equation of motion, Precession of Mercury, Deflection of light

Recording

https://drive.google.com/file/d/1DmO\_ZEqEx1-1EkgKz7JPQM\_dG1Qq8YBd/view?usp=sharing

PPT

https://drive.google.com/file/d/1N4v1aWRSmzAZLoSZrAybrE6WcuuY3aBj/view?usp=sharing

Lecture 10 Quantum mechanics and Moving Forward. The Need of Quantum mechanics, State space of an object, Observables, Quantum mechanics harmonic oscillator, Hydrogen atom, TPPl overview, Open problems

Recording

<https://drive.google.com/file/d/1sKn5kb9LHWllzp0SbaYOsIh0JElOTA4Z/view?usp=sharing>

PPT

https://drive.google.com/file/d/1a9IIrxnotQjdcR9u-qiOTOqCdz5IjZyB/view?usp=sharing