Theory of Gravitation, Relativistic Astrophysics and Cosmology

(Ph. D. admission syllabus)

1. Physical and mathematical foundations of General Relativity: the Equivalence Principle, Riemannian geometry, the Einstein field equations, geodesic motion, the equation of geodesic deviation, and their relation to Newtonian gravity and tidal forces.
2. Spherically symmetric gravity: Schwarzschild spacetime, the event horizon, the concept of a black hole, Birkhoff's theorem.
3. Observational evidence for General Relativity: the Pound–Rebka experiment, the precession of planetary orbits, and the deflection of light by the Sun.
4. Gravitational lensing: strong and weak lensing, observational aspects.
5. Relativistic stellar solutions, the relativistic equation of hydrostatic equilibrium.
6. Black hole formation from stellar evolution: the Oppenheimer–Snyder collapse.
7. Rotating black holes, results from the Event Horizon Telescope.
8. The theoretical characteristics of the Standard Cosmological Model, cosmological observations.
9. Gravitational radiation in the weak-field regime: the wave equation and polarizations.
10. Indirect and direct detection of gravitational waves: results from LIGO–Virgo–KAGRA and planned detectors.

References

1. C. W. Misner, K. S. Thorne, J. A. Wheeler: *Gravitation*. W. H. Freeman and Company, 1973.
2. R. M. Wald: *General Relativity*. University of Chicago Press, 1984.
3. M. P. Hobson, G. Efstathiou, A. N. Lasenby: *General Relativity: An Introduction for Physicists*. Cambridge University Press, 2006.
4. N. Straumann: *General Relativity: With Applications to Astrophysics*. Springer, 2004.
5. L. Á. Gergely: *Theory and Detection of Gravitational Waves by Laser Interferometric Methods*. SZTE Course Notes, 2026.