

Study programme: Astronomy and Astrophysics – PhD Studies			
Course: Evolution of supernova remnants			
Teacher or teachers: Bojan Arbutina, Dejan Urošević, Dušan Onić			
Status: optional			
ECTS credits: 9			
Requirements: none			
Course objective: Acquiring advanced knowledge about magnetohydrodynamical and radio evolution of supernova remnants.			
Course outcome: At the end of the course, student has enough skills to start a research concerning magnetohydrodynamical and radio evolution of supernova remnants (shock waves, phase of evolution, radio evolution i.e. Σ -D relation, statistical analysis).			
Course description: Historical introduction. Supernovae: type I and II, supernova rates. Observational characteristics of supernova remnants in optical radio and X-rays. Radio supernovae. Shock waves. Diffusive shock acceleration (DSA) theory. Non-linear DSA. Cosmic rays, magnetic fields and synchrotron radiation from supernova remnants. Hydrodynamical evolution: free expansion, adiabatic phase, radiative phase, dissipation. Radio evolution: Σ -D and L-D relations, statistics of supernova remnants.			
Recommended literature: Vink, J., 2020, Evolution of Supernovae Remnants, Springer Arbutina, B., 2017, Evolution of supernova remnants, Publ. Astron. Obs. Belgrade, 97, 1 Lequeux, J., Falgarone, E. & Ryter, C.: 2004, The Interstellar Medium, Springer, Rohlfs K., Wilson T.L., 1996, Tools of Radio Astronomy, Berlin, Heidelberg: Springer-Verlag, Woosley, S. E., Weaver, Thomas A., 1986, The physics of supernova explosions, Annu. Rev. Astron. Astrophys., 24, 205 Weiler, Kurt W., Sramek, Richard A., 1988, Supernovae and supernova remnants, Annu. Rev. Astron. Astrophys., 26, 295 Vink, J., 2012, Supernova remnants: the X-ray perspective, Astron. Astrophys. Rev., 20, 49			
Exercises: Arbutina B., 2012, Supernovae and their remnants, Belgrade			
Total number of classes: 10	Theoretical classes: 4	Practical classes: 6	
Teaching methods: Ex cathedra, group work, student research			
Grading system (maximum number of points: 100)			
Pre-exam requirements	points	Final exam	points
Activity in class		Written exam	40
Practical work	30	Oral exam	30
Colloquia			
Seminars			