

EUPROMETA – 37th Doctoral School on Metamaterials,
31 August-1 September 2018, Aalto University, Finland

Nonreciprocal and Time-Modulated

Metamaterials and Metasurfaces

School Program

Friday, 31 August 2018

Hour	Topic	Lecturer
9:00 - 10:30	General introduction and fundamentals. Time-reversal symmetry of Maxwell's equations. Definition and origin of reciprocity. Lorentz reciprocity theorem for general linear (bianisotropic) media. Onsager-Casimir symmetry relations. Time- and space-reversal symmetries working together.	Sergei Tretyakov
10:30 - 11:00	Break	
11:00 - 12:30	Fundamentals of space-time modulation, nonlinearity, and topological phenomena for time-reversal symmetry breaking and nonreciprocity. Nonreciprocity through time-space modulation.	Andrea Alù
12:30 - 14:00	Lunch	
14:00 - 15:30	Magnetized epsilon-near-zero (ENZ) material and its nonreciprocal response, including the topological one-way solution at the boundary of magnetized ENZ. Nonreciprocity in the near field in magnetized plasmonic scenarios, that creates energy flow vortex in the near field. Nonreciprocal nonlinear metasurfaces (with varactors and chiral elements).	Nader Engheta
15:30 - 17:00	Break and discussion with the lecturers	
18:00 - 21:00	School dinner	

Saturday, 1 September 2018

Hour	Topic	Lecturer
9:00 - 10:30	Nonreciprocity via magnetic bias and active devices. Cross-flux theorem in electromagnetics. How magneto-optic materials break Rayleigh-Carson reciprocity. Reciprocal and nonreciprocal behavior associated time domain antennas. Antenna and array practical applications.	Richard Ziolkowski
10:30 - 11:00	Break	
11:00 - 12:30	Nonreciprocity and topological insulators through nonlinearity. Nonreciprocal isolators, circulators and antennas through space-time modulation.	Dimitrios Sounas.

12:30 - 14:00	Lunch	
14:00 - 15:30	<p>Numerical methods for analyzing time-modulated systems. (i) Review of static nonreciprocal systems and examples in acoustics. (ii) Theory of time-modulated systems. Floquet-Bloch theorem and coupled mode theory. Time-Floquet lattices. Numerical methods, analytical models versus finite-element simulations. (iii) Application to current topics. Floquet topological insulators. Zero-index time-varying metamaterials. Nonreciprocal mirrors. Nonreciprocal parametric amplification. Link with parity-time symmetry.</p>	Romain Fleury
15:30 - 17:00	Break and Exam	