

Programma 25/26

- **ACTIVE GALACTIC NUCLEI AND BLACK HOLES:** AGN phenomenology, optical, radio and X, including superluminal motions, BPT diagram. Eddington luminosity, accretion rate, time. Unified model for AGN, Radiative efficiency of an accretion disc. Proofs of BH existence: variability, iron line, motion of S2 around SgrA*, EHT. Remnant BHs: scaling relations, Soltan argument, BH mass function, BH seeds and their formation scenarios. Role of AGNs in galaxy evolution (hints).

RADIO GALAXIES: Properties: size and structure, classification (FRI and FRII), Lradio-Lopt, HERG/LERG vs. RE/RI. Physical processes: synchrotron radiation and energy equipartition, steepening of the spectrum and spectral index maps, age of the lobes, X-ray and synchrotron self-inverse Compton radiation, polarization and rotation measure, RG cycle. Host-galaxies. Environment: NAT and WAT, RGs in cool core clusters. Confinement. Fuelling. Feedback: cavity and relation with ICM. Diffuse emission properties: occurrence, size, location and cluster types, spectra and polarization, classification (halos, relics Gischt/Phoenix, mini halos). Radio-X relation. Radio "bimodality". Magnetic fields (hints). Reacceleration models and merger shock/turbulence. Hadronic models.

Radio Astronomy INTRO: the radio window and its advantages, Historical Development of Radio Astronomy, The Golden Age of Discovery (1957–1975), Major Radio Observatories, Modern Discoveries and the Current Frontier, Next-Generation Facilities

Physical Processes in Radio Astronomy: Emission Mechanism Taxonomy, Blackbody Radiation and Radiative Transfer basics, Free-Free Emission (Thermal Bremsstrahlung), Synchrotron Radiation, Synchrotron Self-Absorption (SSA), Spectral Aging, Spectral Line Emission, HI 21-cm Hyperfine Line, Molecular Lines, Radio Recombination Lines and Masers, Magnetic Field Diagnostics, Zeeman Effect. Faraday Rotation, Plasma Propagation Effects, Dispersion Measure

Telescope Design & Radio Receivers: The Reciprocity Theorem, Beam Patterns, Aperture Efficiency, the Ruze equation, Telescope Optical Designs, Telescope Mounts, SEFD and the Radiometer Equation, Array Theory: Beam Steering, Noise Temperature and the Friis Formula, System Temperature, The Quantum Noise Limit, The Heterodyne Chain, Digital Backends

Single-Dish & Interferometry: The Total-Power Problem, What Single Dishes Uniquely Provide, Absolute Flux Calibration, Combining SD + Interferometer: Feathering

Interferometry Principles: The Two-Element Interferometer, Visibility Function and the Van Cittert-Zernike Theorem, Mutual Coherence: The Physical Foundation, Resolution and Maximum Recoverable Scale, Dirty Beam and CLEAN Deconvolution, Sensitivity: Deriving the Interferometric Radiometer Equation, Fringe Washing: Coherence Limits, Calibration, Self-Calibration, Atmospheric Phase Errors, Synthesis Imaging in Practice: Weighting Schemes, Multi-Frequency Synthesis (MFS), Missing Spacings and Flux Recovery, Wide-Field Imaging and the Non-Coplanar Baseline (w-Term) Challenge, Key Interferometers

Data Calibration Techniques: Calibration Framework and the RIME, Calibration Order and Solution Intervals, Complex Gain Calibration, Bandpass and Delay Calibration, Flux Scale Calibration, Polarization Calibration, Direction-Dependent Calibration, Ionospheric Phase Delay, Tropospheric Calibration and ALMA WVR, RFI Flagging

Synthesis Imaging and Deconvolution: CLEAN Deconvolution, The Högbom CLEAN Algorithm, Multi-Scale CLEAN, Cotton-Schwab Major/Minor Cycles, Multi-Frequency Synthesis and Spectral Index, Spectral Line Imaging and Moment Maps, Image Quality Assessment: Thermal Noise and Dynamic Range, Advanced Imaging Techniques, Calibration → Imaging: Self-Calibration, Source Finding and Catalog Production

Milky Way Radio Astronomy: Galactic Structure and the Interstellar Medium, The 21 cm Hydrogen Line, Molecular Clouds and Star Formation

Galaxy Evolution from Radio Observations: Anatomy of the Galaxy SED, Gas and Dust in the ISM, From Light to Physics — SED Fitting, Hunting Star-Formation Rates, Radio and IR — different physics, same massive stars, The radio–FIR correlation, From observation to intrinsic SFR — energy balance, UV vs IR vs Radio — tradeoffs and complementarities, The radio–SFR calibration: Synchrotron-dominated calibration at 1.4 GHz, Free-free calibration at 33 GHz, Major radio continuum surveys, Galaxy classification — UVJ plus radio diagnostics, The star-forming Main Sequence, UV dust attenuation at high redshift, Hidden star formation in distant clusters, Radio AGN feedback in galaxy evolution, The 21 cm HI line: physics, surveys and environment, Molecular gas and the CO tracer, The Schmidt–Kennicutt relation and star-formation efficiency in MS galaxies and starbursts

Advanced Topics & Frontiers in Radio Astronomy: Black Hole Accretion and Horizon-Scale Imaging, The Event Horizon Telescope Technique, The Photon Ring and Black Hole Shadow, Sgr A*: Harder than M87* Despite Being Closer, Space VLBI and the Next-Generation EHT, Fundamental Physics with Pulsar Timing Arrays, The PTA Concept, General Relativity Tests with Binary Pulsars, FRBs, Transients, and Multi-messenger Astronomy, Molecular Gas and Astrochemistry at High Redshift, Dense Gas Tracers and the Star-Formation Law, Dust Continuum as a Gas Mass Tracer, HI and Galaxy Evolution, Epoch of Reionization and 21-cm Cosmology

Present and Future of Radio Astronomy: The Square Kilometre Array: Design Philosophy and Governance, SKA-Low and SKA-Mid Engineering, Data Flow from Antennas to Archive, The Next-Generation VLA (ngVLA), DSA-2000 — The Radio Camera, LOFAR 2.0, The Pathfinder Era: MeerKAT and the galactic center, ASKAP and Odd Radio Circles, LOFAR LoTSS, Big Data and SKA-Scale Computing, The AI/ML Revolution

SZ effect in galaxy clusters: basics of the radiation field, photon-electron scattering, thermal SZ (tSZ) effect on the radiation spectrum, Kompaneets approximation, kinetic SZ (kSZ) effect, kSZ spectral distortion, pairwise kSZ effect.

Analysis of interferometric data: Introduction to the software APSYNSIM Virtual Radio Interferometer, introduction to the software CASA for the analysis of interferometric data cubes, tutorial on interferometric data analysis using forward Bayesian methods.

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