For the 2017 Qualifying Exam, the first question that you will be asked following your research presentation, and any questions related to it, will be drawn from the list below. You may be asked more than one question from this list.

RADIATIVE PROCESSES

- A. Derive the total power and characteristic frequency of synchrotron radiation from a relativistic particle of mass m, charge e, and energy E moving in a magnetic field B. Use this to explain why synchrotron radiation is generally negligible for protons.
- B. Describe Thomson scattering. What is the angular dependence of the emitted radiation? Under what condition is this dependence valid?
- C. Draw the energy levels of the hydrogen atom and identify which transitions are allowed. Which ones are in the near-infrared part of the spectrum? Which level has no allowed decays, and what is its main decay mode?

INSTRUMENTATION (note that you are responsible only for the course you took, i.e. not optical if you participated only in the radio class)

- D. Describe quantitatively the point spread function of a diffraction-limited optical telescope. Explain how diffraction spikes arise, and what determines their positions and intensities. Under what circumstances will the PSF be broadened by atmospheric turbulence?
- E. Derive a general expression for the signal-to-noise ratio of a point source seen by an optical / near-infrared telescope as a function of seeing, telescope diameter, sky brightness (expressed in mag/arcsec^2), detector noise and dynamic range, and total integration time.
- F. Derive an expression for the point source sensitivity of a radio interferometer as a function of the frequency, bandwidth, system temperature, diameter of each dish, and number of dishes.

STARS

- G. Estimate the temperature as a function of depth in the Sun's convection zone. What is the temperature at the base of the convection zone?
- H. What is the Gamow peak, why is it relevant, what are its dependencies, and how does it factor into the post-main sequence evolution of stars?
- I. Describe the major sources of opacity in stars, and (in graphical form) how each depends on density, temperature, and metallicity. What is the Rosseland Mean Opacity?

GALAXIES

- J. Define two-body relaxation and estimate its time scale in (a) a globular cluster; (b) the Milky Way's disk. In which cases is two-body relaxation important?

- K. Draw qualitatively the spectral energy distribution of the Milky Way, and describe how its morphology might appear to an external observer as a function of wavelength.
- L. Describe at least three methods to probe the gravitational potential of galaxies, their assumptions, and their realm of applicability.

HIGH ENERGY

- M. Work through the physics that determines the maximum possible mass of a white dwarf and the maximum possible mass of a neutron star.
- N. Calculate from first principles the density at which degenerate electrons become relativistic. What temperature would be required to lift the degeneracy?
- O. Derive the Eddington luminosity, and explain the consequences for accretion onto neutron stars and black holes.

INTERSTELLAR MEDIUM

- P. Discuss the main heating mechanisms and cooling transitions that determine the temperature of the principal phases of the interstellar medium: cold molecular, warm neutral, and warm ionized, and hot ionized.
- Q. Draw a typical spectrum of an HII region, including both lines and continuum, and explain the major processes that give rise to each feature.
- R. Explain quantitatively what determines the temperature of dust grains and their thermal emission spectrum. Give examples of astrophysical environments with different dust temperatures.

EXTRAGALACTIC/COSMOLOGY

- S. Put on a timeline, and describe the principal events in the thermal history of the universe, from kT = 10 TeV to kT = 0.1 eV.
- T. Give a semi-quantitative discussion of the connection between flucuations of the cosmic microwave background on angular scales of arcminutes to degrees, and the baryonic structures (galaxies, clusters, correlations of galaxies) observed in the local universe, redshift $z < 0.5$.
- U. Which elements/isotopes are produced in Big Bang Nucleosynthesis and in what quantities? Explain qualitatively how the yield of each depends on the cosmic baryon density and why.