Summary of Lecture 17

Key points include:

1. We can observe our Sun very closely. As an advance notice (more to come in the next lecture), it's tougher with other stars to obtain the mass (for example), but we are helped greatly by binary and multiple stars, where we can use Newton's law of gravity to effectively weigh the stars.

2. Much of the story of astronomy is: what opposes gravity, i.e., what prevents something from just collapsing? In the case of stars such as our Sun, gravity pushes in but pressure pushes outward. The balance between the two is called *hydrostatic equilibrium*. The pressure is produced by the hot gas in the Sun and other stars. The pressure is higher closer to the center, and the heat is produced by nuclear fusion in the core.

3. In the Sun, energy from the core is transported outward. Nearer the core, the transport is by radiation (photons bouncing around); nearer the surface it's convection (rising hot gas). We see the light from the *photosphere*, which has a temperature of about 5,800 K, in contrast to the $\sim$ 15 million K(!!!) of the core.

4. Outside the photosphere, there is a middle layer of the solar atmosphere called the *chromosphere*, and an outer layer called the *corona*. From the corona outward flows the *solar wind*. The corona is much hotter than the photosphere, with temperatures that get up to millions of Kelvin. How can it be that hot? The essential point turns to be that because the corona has very low density it cools very inefficiently and thus can get and stay hot.

5. Sunspots are regions of extra-strong magnetic field on the Sun, and are cooler than most of the photosphere. It's only about 4,000 K versus 5,800 K, but because luminosity goes like T^4, that makes sunspots clearly darker than the rest of the photosphere.

6. For stars, the luminosity is the energy per time emitted by the star. The flux (also called the apparent brightness) is the luminosity per area. The least luminous stars have about 10^{-4} times the luminosity of the Sun, and the most luminous have about 10^6 times the luminosity of the Sun. The coolest stars have photospheres at about 3,000 K and the hottest stars have photospheres at about 50,000 K, compared with the 5,800 K of the Sun.

7. Near the beginning of the 20th century, people discovered that stars congregate in a plot of luminosity versus temperature. This is called the Hertzsprung-Russell (HR) diagram based on the discoverers. On that diagram, the "main sequence" (most stars; this is where stars shine by fusing hydrogen into helium) has higher temperature correlated

with higher luminosity. But there are other parts (the giants and supergiants) which are very luminous although cool, which means that they are very large; and parts (the white dwarfs) that are very dim although hot, which means that they are very small. The HR diagram encodes the lifespans and evolution of stars.

8. The primary thing that determines the lifetime and fate of a star is its mass at the beginning of its life.