Key points from Lecture 17 of ASTR 350

1. In astronomy, a *jet* is a strongly collimated outflow of gas from a system. When the central engine is a black hole, jets can move relativistically; this is not true if, say, the central engine is a protostar.
2. Many questions about jets: how are they formed? How do they relate to the accretion disk? How are they accelerated to relativistic speeds around black holes?
3. Jets can run into their environment and create numerous shapes.
4. Jets often appear to be one-sided, but this is an illusion: there are always oppositely-directed jets, but special relativistic effects mean that the jet coming toward us appears vastly brighter than the jet moving away.
5. Jets can appear to move faster than light. But instead of contradicting special relativity, this appearance is predicted by special relativity. In fact, if the jet is moving with speed v at an angle θ from our direction (i.e., $\theta = 0$ would be directly toward us and $\theta = \pi/2$ would be perpendicular to our direction), then we see the jet moving at an apparent speed
$$v_{\rm obs} = \frac{v \sin\theta}{1 - (v/c)\cos\theta} \ . \qquad (1)$$
This can be many times the speed of light c for v/c close enough to 1.
6. Overall, the relativistic motion of the jet (a) causes apparent variations to happen faster, (b) blueshifts radiation, (c) can create apparently superluminal speeds, and (d) dramatically increases the flux we see.
7. Jets are thought to form via interaction of the gas in the rotating accretion disk with the magnetic fields in the disk; lots of details are still being worked out.