Non-obvious controls:

- You can grab the lines of the excited states in the energy level diagram and move them up and down.
- Be sure to try all the different tabs at the top of the simulation.
- You can **Pause** the sim and then use **Step** to incrementally analyze.
- If you are doing a lecture demonstration, set your screen resolution to 1024x768 so the simulation will fill the screen and be seen easily.

Important modeling notes / simplifications:

- The purpose of the first tab is simply to help students learn about absorption and emission. To explore lasing, it works much better to use the second tab.
- To get lasing, the lamp frequency should match the excitation frequency of the 2nd excited state, the lifetime of the 2nd excited state should be small, the lifetime of the 1st excited state should be large, and the mirror reflectivity should be high.
- We use the convention of labeling the ground state as "1," the first excited state as "2," etc. Another common convention is labeling the ground state as "G," the first excited state as "1," etc. If your textbook and/or course materials use the latter convention, point out the discrepancy to your students. (Note that old versions of this simulation used the latter convention. It was changed in May 2008.)
- When the atom transitions from the second excited state to the first excited state, it emits an infrared photon. These photons are not shown unless you select **Display photons emitted from upper energy state**.
- If you turn up the light intensity very high, you can excite an atom with one photon and then create stimulated emission with the next photon before the atom can decay spontaneously. In real life this process is very rare unless the system is lasing.
- In order to make lasing possible in such a small system, the likelihood of absorption and stimulated emission are higher than in real life. They are set to make lasing as easy as possible while showing that not every photon causes absorption or stimulated emission. You can change the stimulation likelihood in the **Options** menu.
- For simplicity, the mirrors have the same reflectivity for all colors of light.

Insights into student use / thinking:

- We recommend starting with the first tab to help students learn the basic ideas with a single atom. The second tab can be overwhelming if it is the first thing students see.
- Students sometimes have trouble relating what they see in the simulation to the parts of a real laser. **View Picture of Actual Laser** should help with this.
- In interviews, we found that even students with no science background were able to figure out the basics of how a laser works by playing with this simulation.

Suggestions for sim use:

- For tips on using PhET sims with your students see: **Guidelines for Inquiry Contributions** and **Using PhET Sims**
- The simulations have been used successfully with homework, lectures, in-class activities, or lab activities. Use them for introduction to concepts, learning new concepts, reinforcement of concepts, as visual aids for interactive demonstrations, or with in-class clicker questions. To read more, see **Teaching Physics using PhET Simulations**

- For activities and lesson plans written by the PhET team and other teachers, see: **Teacher Ideas & Activities**
- Use lasers as a context for helping students understand atomic transitions, absorption, and spontaneous and stimulated emission.
- Challenge your students to make a working laser. (They will need to maximize the lifetime of the 1^{st} excited state and minimize the lifetime of the 2^{nd} excited state.)
- Challenge your students to make a laser so powerful that it explodes!
- Challenge your students to figure out ways they could fix a broken laser.
- Ask your students to explain the reasons for each of the conditions for lasing.
- Ask your students to explain why three levels, and not just two, are required to make a laser.