**Non-obvious controls:**

* Be sure to try all the different tabs at the top of the simulation.
* You can change the **sample atom**. Each type of atomic nucleus has a different magnetic moment and thus a different energy splitting between the spin down and spin up state for the same **magnetic field**.
* To excite the nuclei, you must turn on the **radio wave source** and tune the **frequency** of the radio waves to match the excitation frequency between the spin down and spin up states. This excitation frequency depends on the **magnetic field**.
* In the second tab, you can excite the nuclei in one small region by adjusting the **horizontal** and **vertical gradients**.
* 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:**

* This simulation is based on the model of MRI presented in Louis Bloomfield’s textbook, *How Things Work*.[[1]](#footnote-1)

**Insights into student use / thinking:**

* We recommend starting with the first tab to help students learn the basic ideas of how to excite nuclei with a constant magnetic field. The second tab can be overwhelming if it is the first thing students see.
* In interviews, we found that even students with no science background were able to figure out the basics of how an MRI works by playing with this simulation.

**Suggestions for sim use:**

* For tips on using PhET sims with your students see: [**Guidelines for Inquiry Contributions**](http://phet.colorado.edu/teacher_ideas/contribution-guidelines.php)and [**Using PhET Sims**](http://phet.colorado.edu/teacher_ideas/classroom-use.php)
* 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**](http://phet.colorado.edu/phet-dist/publications/Teaching_physics_using_PhET_TPT.pdf)
* For activities and lesson plans written by the PhET team and other teachers, see: [**Teacher Ideas & Activities**](http://phet.colorado.edu/teacher_ideas/index.php)
* Use MRI as a context for helping students understand magnetic moments, spin, and energy splitting between spin states.
* Ask students to calculate what **frequency** should excite the nuclei for a given **magnetic field** or vice versa, and use the simulation to check their calculations.
* Give students a table of magnetic moments for different atoms, and ask them to use the simulation to determine the mystery **sample atom** (marked “???”).
* Turn off **Show atomic nuclei**, then **add tumor**, and ask students to determine where the tumor is by tuning the **frequency** to match the energy splitting and seeing where the most photons are emitted.

1. L. Bloomfield, *How Things Work: The Physics of Everyday Life*, Wiley (2006), pp. 526-527. [↑](#footnote-ref-1)