PHYSICAL REASON FOR THE RELATIONSHIP BETWEEN Q AND THE FWHM

What is the reason for this surprising relationship between the damping and the width of the resonance? Fundamentally, it has to do with the fact that friction causes a system to lose its "memory" of its previous state. If the Pioneer 10 space probe, coasting through the frictionless vacuum of interplanetary space, is detected by aliens a million years from now, they will be able to trace its trajectory backwards and infer that it came from our solar system. On the other hand, imagine that I shove a book along a tabletop, it comes to rest, and then someone else walks into the room. There will be no clue as to which direction the book was moving before it stopped --- friction has erased its memory of its motion.

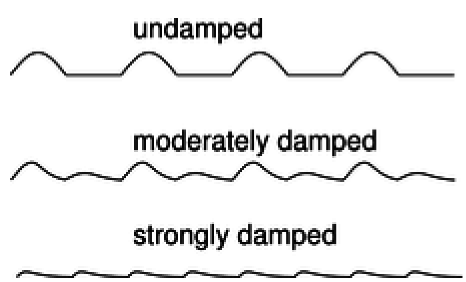

Figure m: An x-versus-t graph of the steady-state motion of a swing being pushed at twice its resonant frequency by an impulsive force.

Now consider the playground swing driven at twice its natural frequency, figure m, where the undamped case is repeated from figure b on page 171. In the undamped case, the first push starts the swing moving with momentum p, but when the second push comes, if there is no friction at all, it now has a momentum of exactly $-p$, and the momentum transfer from the second push is exactly enough to stop it dead. With moderate damping, however, the momentum on the rebound is not quite $-p$, and the second push's effect isn't quite as disastrous. With very strong damping, the swing comes essentially to rest long before the second push. It has lost all its memory, and the second push puts energy into the system rather than taking it out. Although the detailed mathematical results with this kind of impulsive driving force are different,[12] the general results are the same as for sinusoidal driving: the less damping there is, the greater the penalty you pay for driving the system off of resonance.

Most good audio speakers have $Q \approx 1$, but the resonance curve for a higher-Q oscillator always lies above the corresponding curve for one with a lower Q, so people who want their car stereos to be able to rattle the windows of the neighboring cars will often choose speakers that have a high Q.

Of course they could just use speakers with stronger driving magnets to increase Fm, but the speakers might be more expensive, and a high-Q speaker also has less friction, so it wastes less energy as heat.

One problem with this is that whereas the resonance curve of a low-Q speaker (its "response curve" or "frequency response" in audiophile lingo) is fairly flat, a higher-Q speaker tends to emphasize the frequencies that are close to its natural resonance. In audio, a flat response curve gives more realistic reproduction of sound, so a higher quality factor, Q, really corresponds to a *lower* -quality speaker.

Source:
http://physwiki.ucdavis.edu/Fundamentals/03._Conservation_of_Momentum/3.3_Resonance