The hysteresis losses are proportional to the frequency, in the first approximation. With every cycle of the *BH*-hysteresis loop the magnetic field will lose an amount of energy *ΔW*; the higher the frequency the higher the number of cycles per second and the higher the dissipation losses. For the string, however, one has to consider that higher frequency partial tones are damped more strongly by other mechanisms and that the strength of the magnetic flux change depends on the displacement. However, the displacement decreases for higher frequencies. The lower pictures in Fig. 4.56 clearly show that the magnetic field does not have any effect in the high frequency range. In addition, for low frequency partials, one should not overestimate the field-induced dissipations. Finally, for comparison, the influence of the **fretting hand** on the decay of the partials is shown (**Fig. 4.57**, left picture). The upper curve shows a measurement in which the guitar was suspended from a steel wire at the strap button, whereas for both of the lower curves the guitar was clamped at the strap button. For the remaining measurements the fret hand surrounded the neck with different tightness but without touching the strings. All measurements were done without magnetic fields. One recognizes that even without magnetic field a variable dissipation is generated – the **heel of the hand** touching the neck has to be interpreted as damping resistance. Its energetic (!) influence on the sustain is considerably larger than that of a common pickup-magnetic-field (right picture).

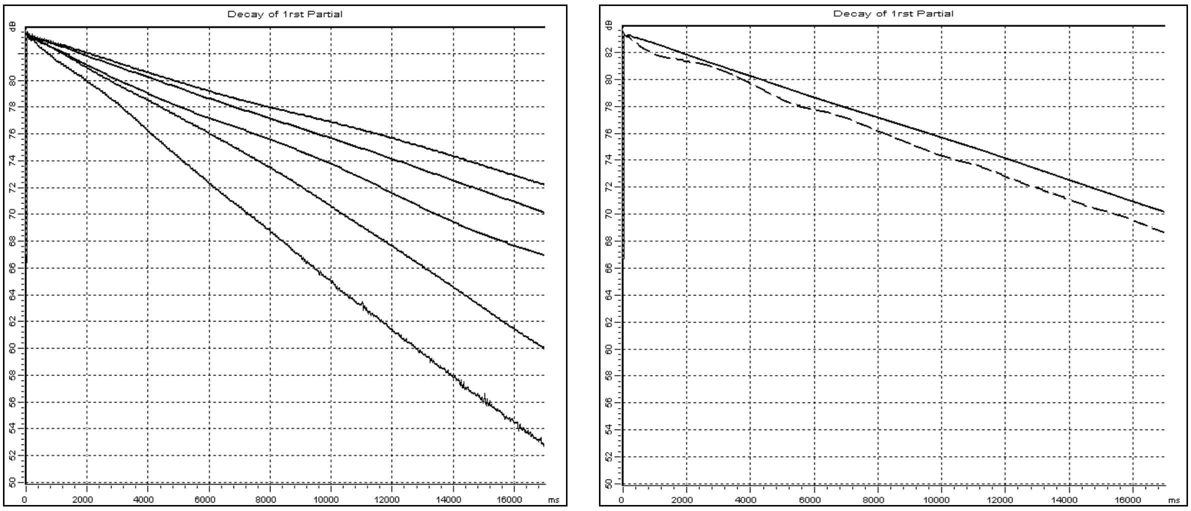

Fig. 4.57: Decay of the first partial tone for different manners of hand-damping (left). On the right, with identical scaling, the influence of an Alnico-5-magnet attached at a distance of 2.5 mm is depicted (neck-position).

4.11.5 Indirect Effects on Sound

In professional music magazines magnet-characteristics are often published without physical rationale. It is to be feared that the following citations are pure speculations resulting from findings after the replacement of an *entire* pickup. In addition, one can only hope that the author also did not replace the strings (… the new pickup delivers much more treble …). For an old Stratocaster pickup, for example, it is impossible to *solely* change the magnets; the coil rests directly on the magnets and as soon as one pulls them out one destroys the flimsy coil-wire. If, however, the whole pickup is replaced by another, the number of turns may change – and, consequently, it would be incorrect to attribute changes in sound only to the magnet.

In literature very different characteristics are attributed to the magnet material, as can be seen by the following collection of citations:

a) “For a pickup with the rather weak Alnico-2 magnet the tone seems to virtually die out after hard plucking. The output signal is not only more quiet but also seems to be less dynamic and perceptibly compressed in the treble range – which is actually appreciated by many guitarists.”
b) “As the magnetic field of an Alnico-II magnet is somewhat weaker than that of a common Strat-pickup (Alnico-V), the string vibration decays more open and more natural. The result is an improvement in sustain.”
c) “Alnico-5: Strong and clear sound.”
d) “Alnico-5: Fast responsiveness and slightly undifferentiated reproduction.”
e) “The stronger the magnet, the more treble.”
f) “As time goes on, older magnets lose some of their power. The less power the magnets have, the better the strings can vibrate. So maybe after 30 years, the magnets are at their 'ideal' power, thus producing 'ideal' tone.” ☺

One might add: “If someone has some Les-Pauls lying around that are older than 30 years – throw them away! Especially for the 50’s Les-Pauls the magnets are completely shot, all power lost, get rid of them. The author will accept these guitars for research sake, at a small waste disposal charge.”

Still, back to the physics. The pickup-magnet is part of a mechanic-electric transducer and as such it influences both the mechanical as well as the electrical partial system. Mechanically the magnet retroacts on the vibrational characteristics of the string; the result can be chorus-like beat frequencies and – to a minor extent – dissipation. The **electrical effect** of the magnet does not really belong in chapter 4.11 because the forces or mechanical effects are described there. The following listing is, therefore, only a precis: The reversible permeability of the magnet influences the inductance of the pickup coil and, consequently, the **resonance frequency**. If the resonance frequency is shifted, partials with different decays may influence the sound and the perceived “sustain”; however, this should not be mixed up with a more openly vibrating string – changes in the cable capacity would have a similar effect. Eddy currents within the magnet influence the **resonance quality factor** (Alnico conducts, ferrite is an insulator). Stronger magnets may increase the **output voltage** of the pickup and overdrive the amplifier in a different way; this may also change the sound and perceived sustain – as well as by changing the input gain. A replacement of the magnets may also change the **aperture** because the spatial flux distribution may change as a function of the (non-linear) string saturation and because the anisotropy of the new magnets may be different from that of the old ones.

The magnetic material can, thus, indeed influence the (“electrical”) sound of the guitar. A hindrance to the free string vibration, however, is not to be expected if the string/magnet-distance is chosen properly.