2.2 Modeling of reflections with mirror waves

As long as the wave impedance of a string remains the same at all locations, there is an unperturbed wave propagation. Conversely, any local change in the wave impedance has the effect of part of the wave reversing its direction and running back to the source (i.e. it is reflected). Particularly strong changes happen at the bearing points of the string: the bearing impedance F/v is very high, while v is almost zero due to the small bearing compliance. In an acoustic guitar, the bridge needs to feature a certain compliance in order to feed part of the energy of the string vibration to the guitar body (and have it radiated as airborne sound from there). For the electric guitar, however, the radiation of sound via the body is not a priority; the **impedance** of the bearing points is very high, and the velocity of the bearing points is approximately zero.

A reflection at a bearing may be described in two ways: either we consider the perturbation of the wave impedance and formulate laws for the reflection, or we ignore the change in the wave impedance and force the bearing condition $v = 0$ via two waves running against each other. Let us apply the latter approach here: the wave propagating in the direction of the bearing is supplemented by a **mirror wave** that runs towards the bearing from the other side. Both waves can run across the bearing in an undisturbed (!) fashion – just as if the bearing points would not exist at all. The parameters of the mirror wave need to be chosen such that at every point in time the bearing condition of $v = 0$ at the bearing persists. The wave and the corresponding mirror wave add up; the sum emulates the reflection process.

Fig. 2.9 shows a triangular displacement wave running to the right towards the bearing indicated by a vertical line. In the right-hand section of the figure, a mirror wave runs towards the first wave; the two displacement waves are point-symmetric (for this bearing that is defined as being un-yielding). Correspondingly, the velocity is shown in the middle graph. Due to the point-symmetric character, displacement and velocity are always zero at the bearing. Via the wave impedance (carrying a sign), we arrive, starting from the velocity, at the axisymmetric force (graph on the right). However, this v-F-transformation only holds for the individual waves but not for their sum. The actual bearing force is double the force that would exist for the individual unperturbed wave running across the bearing. Using the above sign definition we get: **displacement and velocity are reflected with opposite phase, the force is reflected with the same phase**. It does not make any difference in the function graphs whether we interpret the wave running towards the right in Fig. 2.9 as the cause that has as effect a reflection running towards the left, or whether we see it the other way round (i.e. the wave running towards the left is reflected towards the right). Identical graphs result from both cases.

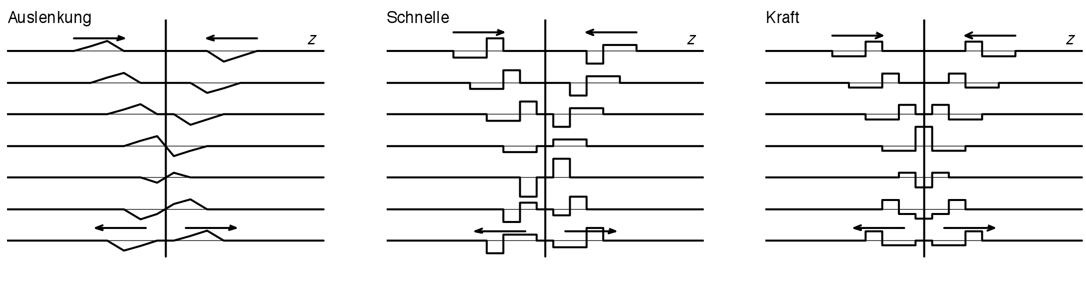

Fig. 2.9: Model of the reflection via a mirror wave running in the opposite direction. The bearing is in the middle of each graph. We see 7 consecutive points in time from top to bottom.
"Auslenkung" = displacement, "Schnelle" = particle velocity, "Kraft" = force.

