String Compensation/Intonation

Knowledge of the harmonic content of the triangle-waves on guitar strings can also be used in other ways. For example, for electric guitars, which of necessity use magnetically-permeable strings - e.g. steel or stainless steel on the higher, lighter-gauge plain strings, and on the lower, heavier-gauge wound strings, steel/stainless steel wrapped with steel/stainless steel or nickel, or nickel-alloy, because of the differences in stiffness of the lighter-gauge plain strings vs. heavier-gauge wound strings, and the action (height of the strings off of the frets on the fretboard) the effective scale length, L_{scale} associated with each string is in fact not precisely the same for each string. Thus, because of this, the bridge of electric guitars often has individually adjustable string saddles, such that the overall length of each string can be adjusted precisely to compensate for these non-linear effects, such that if the all of the open (*i.e.* unfretted) strings of the guitar are in tune with each other, then they will also be in tune with each other e.g. an octave above the open strings. Some guitar manufacturers, such as Gibson, will also additionally slant the bridge with a small rake-angle, such that the scale length for each string systematically increases from the high-E to the low-E strings.

Because the high-E string on a guitar is the thinnest gauge plain string - typically 0.009”-0.011” in diameter, the scale length associated with the high-E string is closest to the physical, or true scale length of the guitar - i.e. the distance measured from the inner edge of the nut (facing the fretboard) to the string contact point of the high-E string at the bridge. The physical scale length of the guitar is also that which precisely determines the location of each of the frets along the fretboard, referenced to the inner edge of the nut (the zero of the frets). The B-string on a guitar is the next thinnest gauge plain string, typically 0.011”-0.013” in diameter. Its overall length, for proper intonation over the full length of the guitar neck needs to be slightly longer than for the high-E string, requiring the bridge saddle for the B-string to be shifted back, relative to the bridge saddle of the high-E string typically by a distance of ~ 0.5-1.0 mm. The G-string, which is the thickest gauge plain string - typically 0.014”-0.017” in diameter, requires even longer overall length for proper intonation over the full length of the guitar neck, requiring the bridge saddle for the G-string to be shifted back relative to the high-E string a typical distance of ~ 1.0-2.0 mm. For the wound strings, the D-string, which is the lightest gauge wound string, typically 0.024”-0.026” in diameter, does not require as much compensation as the plain G-string; typically the D-string bridge saddle needs to be moved back relative to the bridge saddle of the high-E string typically by ~ 0.5-1.0 mm, comparable to that of the B-string compensation. The A-string, which is the next thickest gauge wound string, typically 0.032”-0.036” in diameter, requires its bridge saddle to be shifted back relative to the high-E string a distance of 1.5-3.0 mm, for proper intonation over the full length of the fretboard. Finally, the low-E string, which is the thickest gauge wound string, typically 0.042”-0.046” in diameter, requires the largest string compensation, the bridge saddle for the low-E string must be shifted back relative to the string saddle for the high-E string typically by an amount of ~ 3.0-4.0 mm.