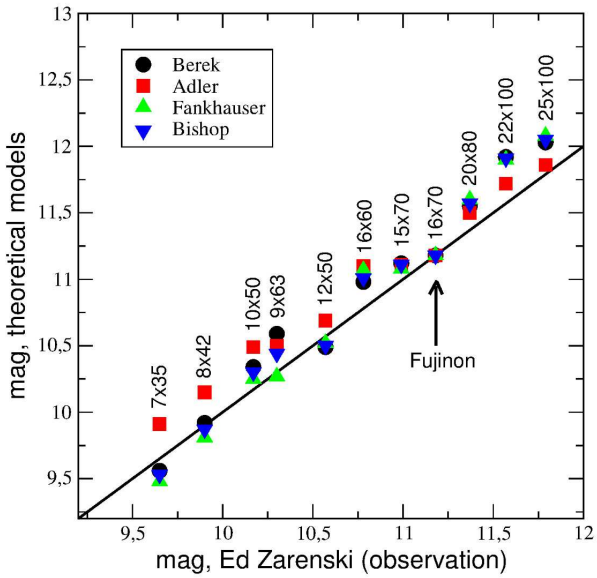
the magnifications $m_2 = 2m_1$. Both are having identical exit pupils and thus yield identical background luminances to the observer's eye (assuming identical transmission values). This immediately leads to the ratio of their performance indices, $I_{B,2}/I_{B,1} = D_2^2/D_1^2 = 4$, consistent with the conservation of the luminous flux. Given the rather general case of non-identical exit pupil diameters, the situation is turning complex, since the evaluation of the specific luminance function $\phi(\tilde{L}_{\mathrm{sky}})$ is now required. This function is non-linear (figure 9.3) and does not lead to any simple power-law function of D and m, as proposed in equation (10.19). The luminous flux is still conserved, but the perception of brightness differs with the level of retinal adaptation, so that the conservation law is no longer manifest in the most general form of equation (10.27).

10.5.4 Comparison with observation data

For a perfect 16x70 binocular we obtain the Berek index of $I_B = 139.2$. Assuming the limiting magnitude of the bare eye to be 6mag, we would gain $\log 139.2/\log 2.152\mathrm{mag} = 5.36\mathrm{mag}$ with the instrument and arrive at the limiting magnitude of 11.36mag. Taking figure 10.9, we find that Ed Zarenski reported a limiting magnitude of 11.18mag with his 16x70 binocular, which seems sufficiently close to our theoretically derived value, when considering that no instrument is perfect in terms of transmission, stray light and absence of aberrations. We note that another assumption has entered our calculation, namely that the eye reaches its limiting magnitude of 6mag in combination with the background luminance of $0.001\mathrm{cd/m^2}$.

To avoid pitfalls that may be encountered with these kind of assumptions, it is advisable to normalize the set of observations to the data raised with one particular instrument and to compare only relative performances, i.e. gains and losses with respect to that reference binocular. We choose the Fujinon



10.10

Limiting magnitudes (in mag) of stars, obtained with different binoculars. Several theoretical indices are plotted over the observational data of Zarenski (figure 10.9) at a bare eye limiting magnitude of 6mag. All theoretical magnitudes are normalized to the observation point of the 16x70 Fujinon, the diagonal defines the identity of observation and theory.

16x70 FMT-SX of Zarenski's data set, which is likely to be the highest quality device of the lot. To evaluate the pupil size of the observer, we apply equation (8.1), assuming a young observer and an apparent field of view of 60° for all instruments [11].

In figure 10.10, the theoretical predictions are plotted over the observational data of Zarenski. It is interesting to note how closely the predictions of the different models agree with the observations and with one another: Though deviations exist, they

[11] Deviations arising from that latter assumption would lead to tiny modifications of the results which are conveniently neglected.