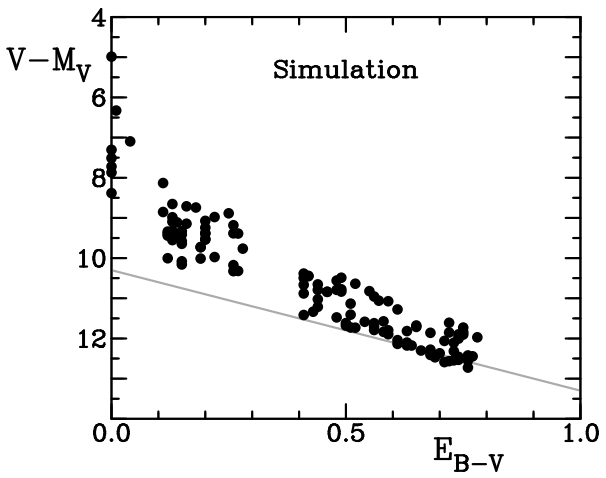

Fig. 4. A simulated variable-extinction diagram for a star field where the reddening increases with distance according to dust clouds producing $E_{B-V} = 0.20$, 0.50, and 0.70 located at distances of 0.5 kpc, 0.9 kpc, and 1.1 kpc, respectively, with associated uncertainties in E_{B-V} of ± 0.05 and in M_V of ± 0.5. The gray line denotes a standard reddening law of $R = A_V/E_{B-V} = 3.0$ for stars at a distance of 1.1 kpc.

to some of the variable-extinction diagrams of Figure 3.

The large range of inferred reddenings for field stars near each Cepheid was reduced further through an analysis of 2MASS observations (Cutri et al. 2003) for likely BAF-type stars in the same fields, analyzed in similar fashion to that employed by Turner et al. (2008) and Turner (2011). 2MASS observations were used separately without combination with the $BV(RI)_C$ photometry in order to avoid potential zero-point problems. The observed J–H and H–K_s colors for stars lying within 5′ of each Cepheid are shown in Figure 5, and were compared with the intrinsic relation for main-sequence stars in the 2MASS system (Turner 2011), adjusted with a reddening slope $E_{H-K}/E_{J-H} = 0.49$ from Turner (2011). Multiple solutions in some cases, e.g., UY Mon and HZ Per, were resolved with reference to the variable-extinction diagrams and "predicted" values, and best fits were made by trial and error by establishing reddenings for which likely BAF-type stars had colors distributed randomly about the reddened intrinsic relation.

The JHK_s colors generate independent E_{B-V} reddenings for the stars in the Cepheid fields, with the advantage of being more closely tied to B-type stars in the fields, stars that lie blueward of the "kink" in the intrinsic relation and that may share a common origin with the Cepheid. The reddenings have slightly larger uncertainties because of larger photometric scatter in the observations (by factors of 3–5 relative to the $BV(RI)_C$ photometry) in combination with the correction from infrared to optical reddening. They are nevertheless crucial for narrowing the range of potential color excesses for some of the sample Cepheids, such as IO Cas. A few objects in the sample appear to be Type II Cepheids, but that does not affect the results. In most cases the implied reddening near the Cepheid is fairly evident.

4. RESULTS

The results of the variable-extinction studies of the sample Cepheids are presented in Table 2, which lists the inferred space reddening for each Cepheid derived from likely AF-type stars lying within different angular radii, from 2′ to 5′ distant, and the reddening inferred from 2MASS JHK_s colors for stars within 5′ of the Cepheid. The adopted color excess in each case, Column 8, was the average for all AF-type stars lying within 5′ of the Cepheid and of comparable inferred distance, and the resulting reddening, which is equivalent to that for a star of spectral type B0, was converted in the last column of the table to a value appropriate for the derived intrinsic color of the Cepheid, again using the relationship of Fernie (1963). The number of stars used to obtain the space reddening is listed in the second last column of Table 2. In rich fields that number is of order ∼10–20, whereas in more poorly populated regions or fields with a larger spread in reddening, less than half a dozen reference stars were available. Two solutions are presented for UY Mon, for reasons indicated later, although the adopted solution for the Cepheid is the first.

It is worth noting that the 2MASS reddenings fall closer to the converted color excess for the Cepheid than to the B0-star reddenings. A reasonable explanation lies in the fact that the BAF-star reddenings in a 2MASS color-color diagram tend to be dominated by the AF stars, particularly likely F-type stars, since B-type stars are less common in the small fields analyzed and are potentially affected by circumstellar effects (Turner 2011). The 2MASS reddenings are also important for providing confirmation of the relationship used to convert B0-star color excesses to those appropriate for a star with the average unreddened colors of the Cepheid, which are very similar to F-type dwarfs in the 2MASS samples.

The derived intrinsic colors are presented in Table 3, which also provides in Column 3 the variable