On the determination of the redshift of high-z supernovae from the observed $z - J$ and $J - H$ color indexes

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In this memo I describe the calculations I did in order to check the feasibility of getting the redshift of supernovae from multicolor photometric observations alone. This work is done in the context of the 2004 *HST* search and follow-up of high-redshift supernovae, and assumes that the observations will be performed in the ACS z-band, and NICMOS J and H bands.

I used the $s = 1$ spectral and $UBVR$ templates to compute the zJH-band light curves of SNe at redshift 1.2, 1.3, 1.4 and 1.5. The $UBVR$ templates I use are generated in a very similar way to that in the HST paper. The B-band template is unchanged. The U template is based on Jha's thesis data and VR templates on Hamuy, Riess and Jha data sets. The assumed $U - B$ color index at the time of B maximum light $t_{B_{max}}$ is $(U - B)_{B_{max}} = -0.22$. The spectral template was then warped by using P. Nugent's program to match the photometric templates.

Then, I computed the relevant K-corrections:

z=1.2	$z \to B$	$J \to V$	$H \to R$
z=1.3	$z \to B$	$J \to V$	$H \to R$
z=1.4	$z \to U$	$J \to V$	$H \to R$
z=1.5	$z \to U$	$J \to B$	$H \to R$

to obtain the observed zJH light curves of a $s = 1$ SN. The time evolution of $z - J$ and $J - H$ color indexes (hereafter I will use *observer's frame days* wrt $t_{B_{max}}$) are presented in Figs. 1*a* and *b*. The corresponding $z - J/J - H$ color-color diagram is shown in Fig. 1*c*. The blue lines show the case of $E(B - V)_{host} = 0.0$ and the red ones $E(B - V)_{host} = 0.1$.

The results of this simple exercise show that 0.1 difference in the redshift results in difference in $z - J$ and $J - H$ color indexes $\sim 0.1 - 0.2$ mag over the interval $-10 \div +30$. Therefore, if the SN observed is a Ia with average intrinsic colors as for "normals", it should be possible to get the redshift from multicolor photometric observations alone, provided that the color indexes are determined with an accuracy better than let say 0.07 mag and $t_{B_{max}}$ is also known with reasonable accuracy. Particularly useful will be the $J - H$ color index because in SNe at different redshifts its evolution follows noticeably different tracks between days -20 and $+25$. Given that we will most probably get 3 observation in each J and H band, it seems then best to distribute these observations evenly over the interval $-20 \div +25$. However, most of the SNe will be discovered around $t_{B_{max}}$, thus I would suggest to try to get the first J and H observations as soon as possible, moreover around maximum higher signal-to-noise measurements are obtained. This would allow to distinguish between different redshifts not only by the (nearly)constant offsets around days $+10 \div +25$ in both $z - J$ and $J - H$, but also by tracking the different evolution of $J - H$.

Although the results of these simple calculations are encouraging, given that only 3 observations will be available, to explore the feasibility of the determination of the redshift based on photometric measurements only, full Monte-Carlo simulations should be run. The simulations

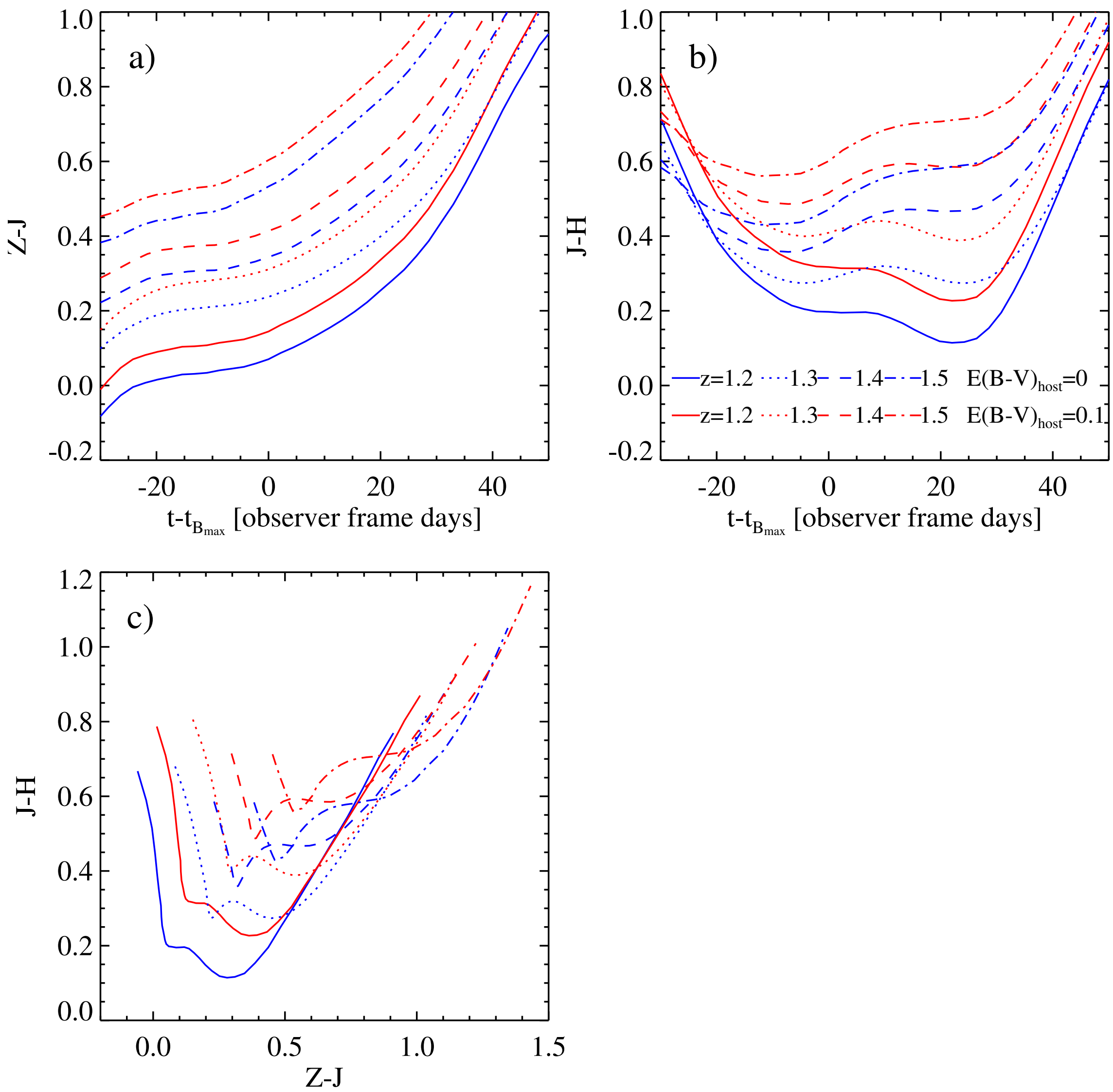

Figure 1: **a** and **b** The observed evolution of $z-J$ and $J-H$ color indexes SN Ia at redshifts 1.2, 1.3, 1.4 and 1.5; **c** the corresponding color-color diagram. The blue and red lines correspond to host galaxy extinction $E(B-V)_{host}$ = 0 and 0.1, respectively.

should also take into account the systematic effects and intrinsic color dispersion of SNe Ia. However, it seems possible to get the redshift with an accuracy ~ 0.1. A few points should be also noted. $t_{B_{max}}$ itself is a function of redshift (through the K-correction). Thus, a first guess should be supplied and iterated until converge. There is a kind of degeneracy between the redshift and host galaxy reddening, especially in $z-J$ at all times and $J-H$ at late times. The different evolution of the $J-H$ color index with the redshift can help break this generally; however, this would require better accuracy of the measured color indexes.