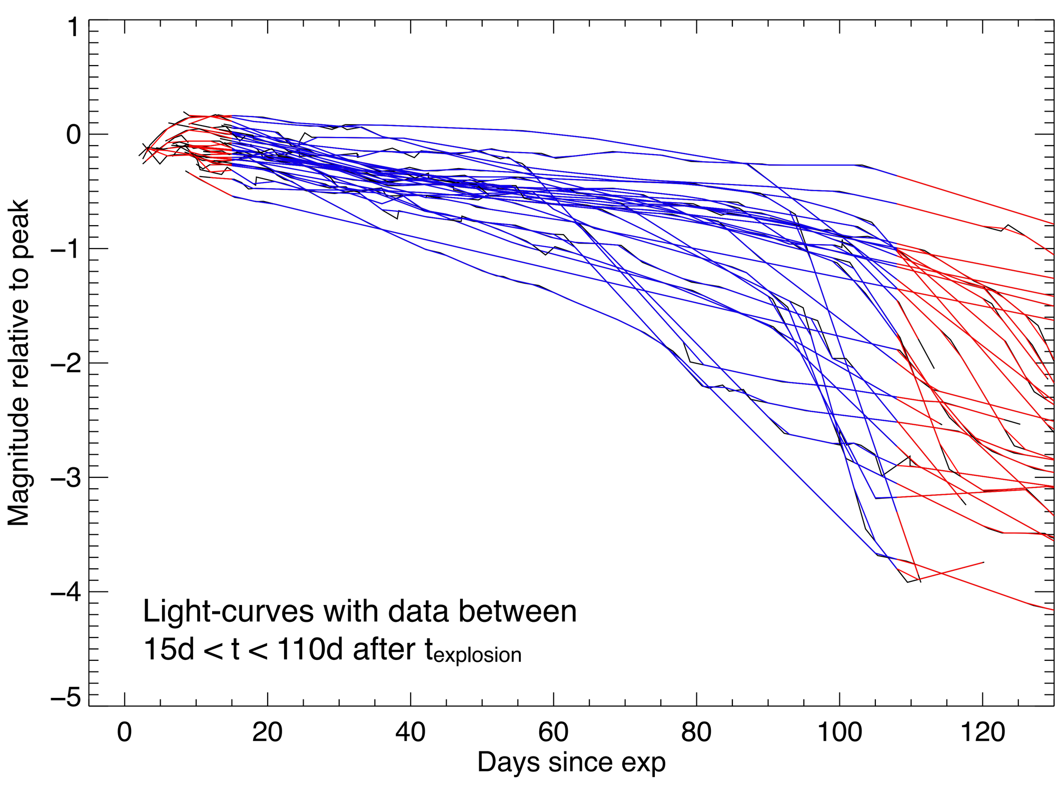
PCA of type II supernova light-curves

Lluis Galbany, Millenium Institute of Astrophysics (MAS) & Departamento de Astronomia U. de Chile (DAS)

We present a Principal Component Analysis (PCA) of the light-curves of a sample of more than 100 nearby Core collapse supernovae (SNe) from several sources, and most of them previously unpublished. We used different reference epochs in order to extract the common properties of these light-curves and searched for correlations to some physical parameters such as the burning of Ni^{56}, amount of Hydrogen, and morphological parameters such as the length of the plateau, the stretch of the light-curve, and the decrements in brightness after maximum and after the plateau. We also used these similarities to create SNe II light-curve templates that will be used in the future for standardize these objects and determine cosmological distances.

Introduction

SNe II represent the most homogeneous set of CC SNe and, although they are on average 1.2 mag intrinsically fainter than SNe Ia, their use as independent cosmological distance indicators has been already demonstrated (Hamuy et al. 2002). They also are the most common of all SN types, although there is a deficit in the literature as compared to the prioritized SNe Ia, especially at higher redshift. The advantages of SNe II as cosmological probes over SNe Ia reside on the simplicity of their hydrogen dominated atmospheres and low-density surrounding media, and on understanding of the explosion mechanism and progenitors stars . These advantages together with their high rates and homogeneity, make SNe II promising independent cosmological probes.



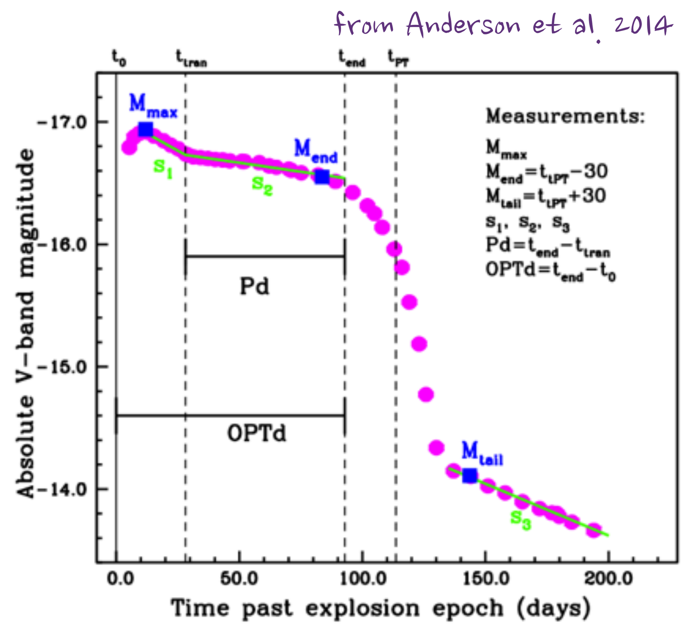
Sample

We have used a sample of 116 SNe II at low-redshift from Anderson et al. 2014 for which several V-band light-curve parameters have been determined and measured.

After several attempts, we found the best correlations by normalizing the light-curves in brightness to the magnitude at the peak, and took the explosion date as the reference epoch.

After having optimized the number of SNe and epochs, our final sample is 29 SNe with available light-curves between 15 and 110 days after explosion.

from Anderson et al. 2014

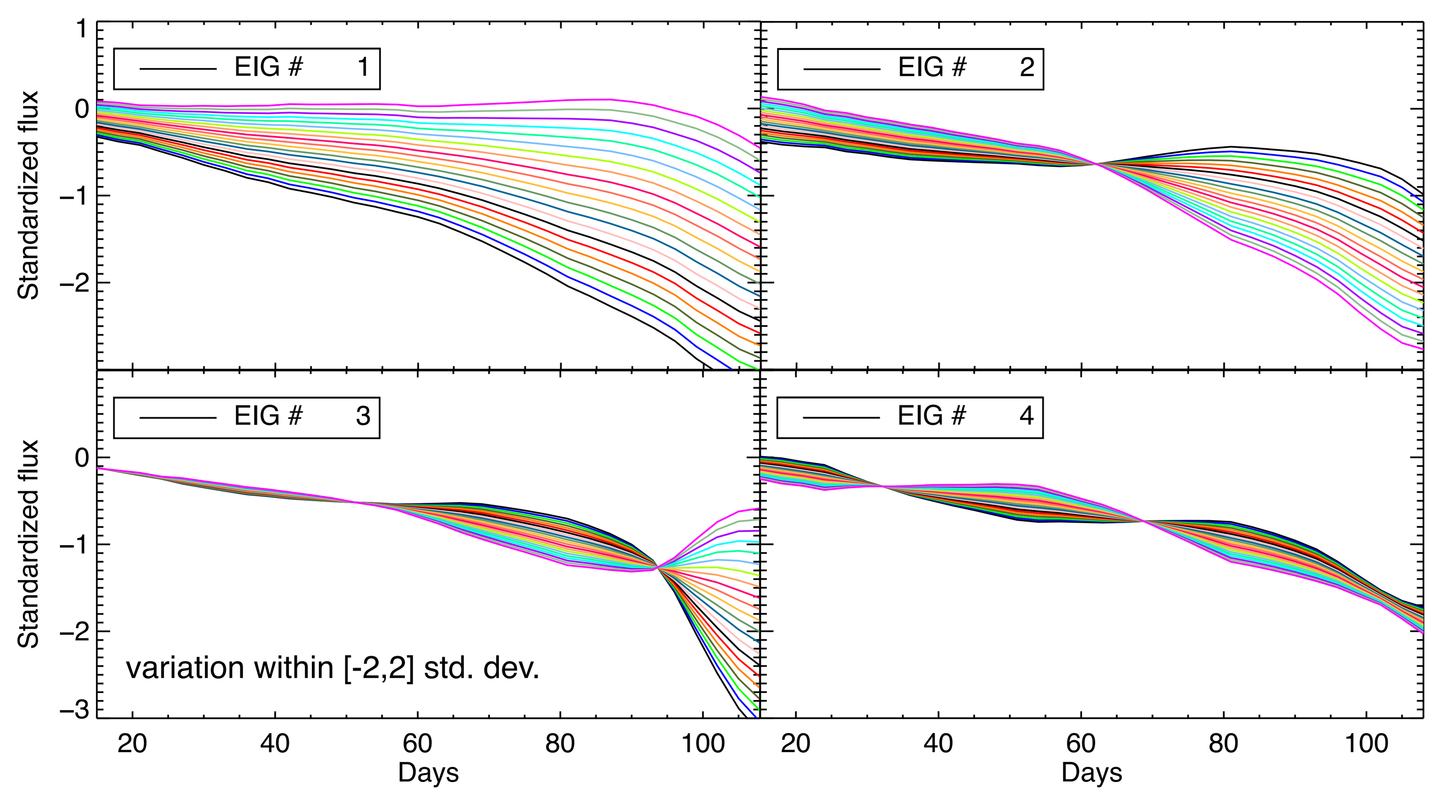


Method

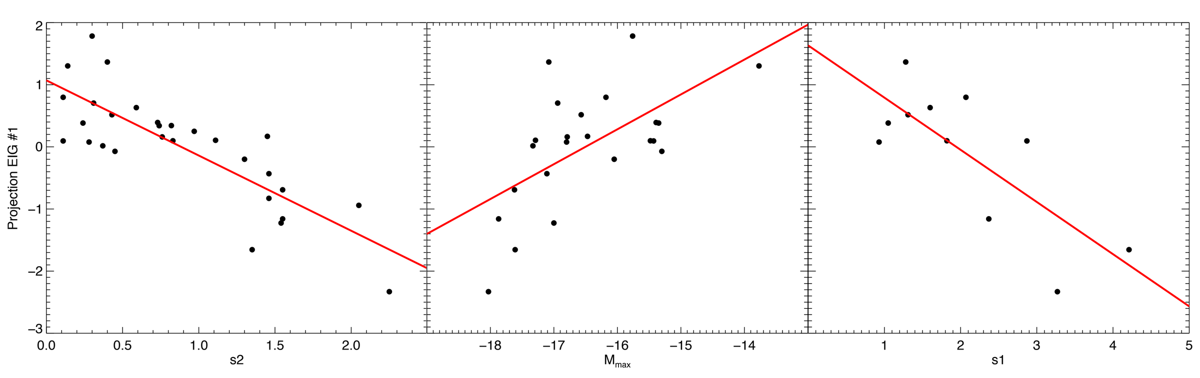
We have performed a Principal Component Analysis (PCA) of the 29x32 matrix containing the 32 epochs for each of the 29 SNe. The PCA gives an orthonormal set of 32 eigenvectors (EV) ordered by decreasing variability, and a matrix of 29x32 projections (one projection for SN and EV). In our case, the first four EVs account for more than the 99% of the light-curve variation.

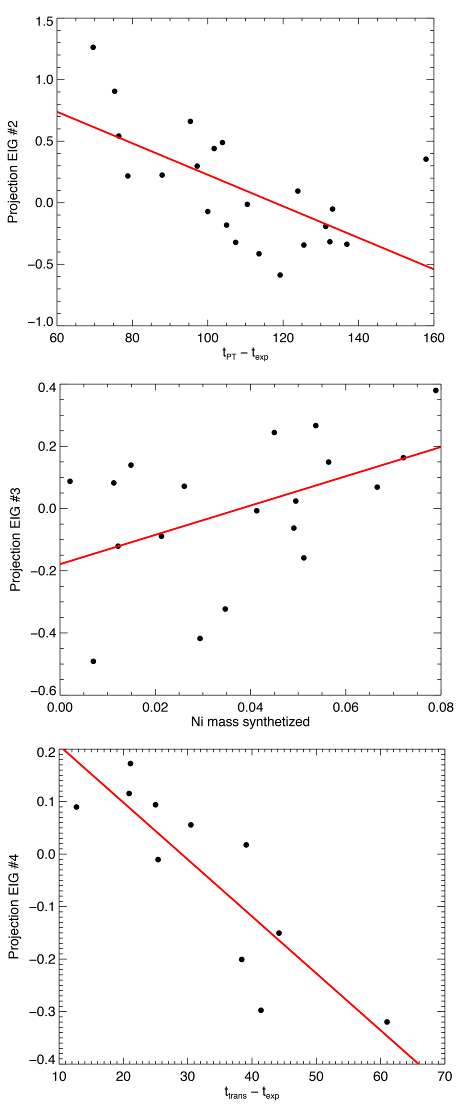
One can see the contribution of this four EV to reproduce a SN light-curve by multiplying the 2-sigma variation of all 29 SN projections in each of these 4 EVs.

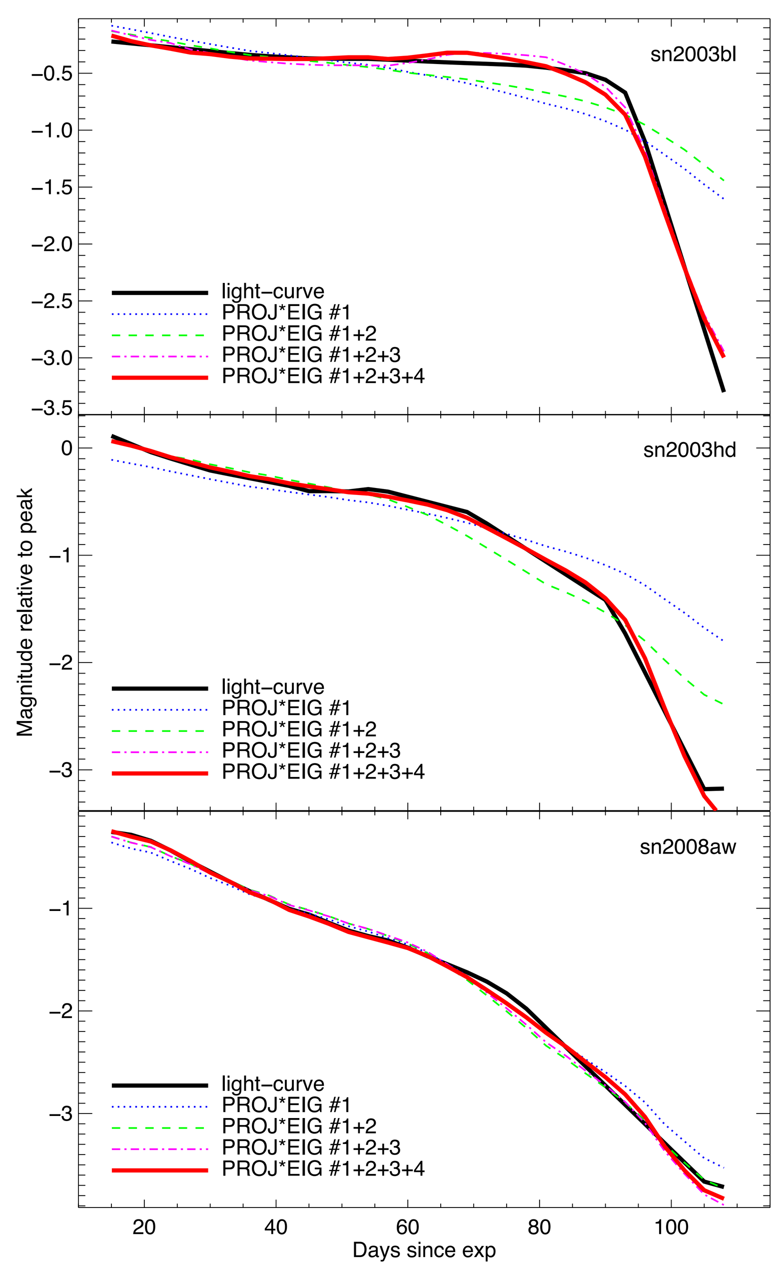
We have then correlated each pair of projection and physical or light-curve parameter for all SNe in our sample, for which the required information was available.



Results







We have found strong correlations between the projections of:

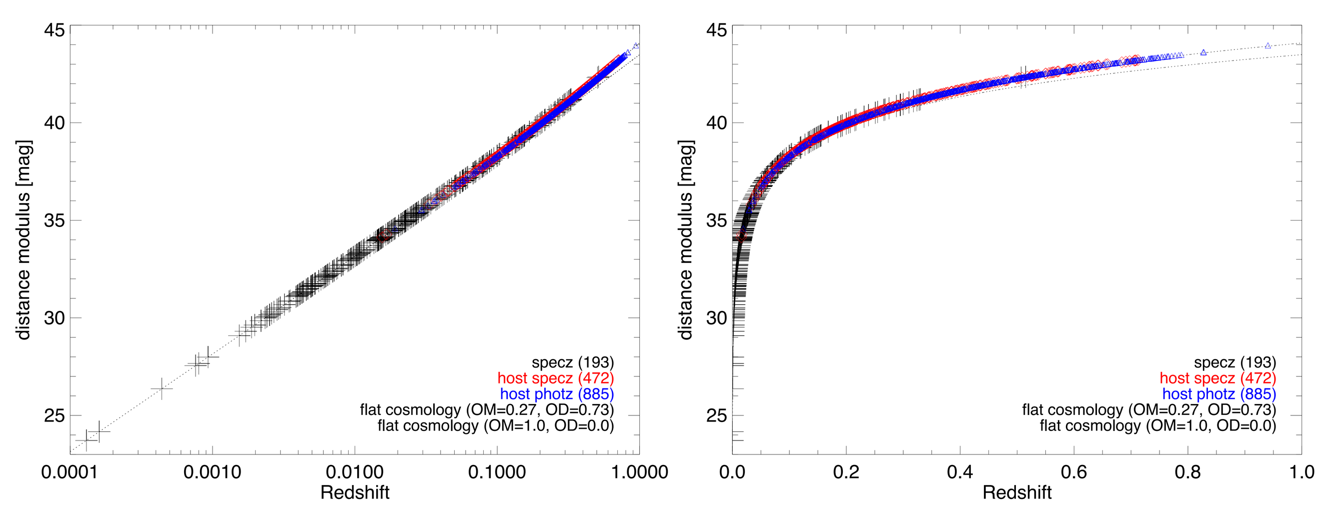
- EV_1 with s_2, M_{max}, and s_1
- EV_2 with t_{PT}
- EV_3 with Ni mass synthesized
- EV_4 with t_{trans}

We have also been able to reproduce the original light-curves with only these four EVs. The agreement is remarkable even with the three first components.

Therefore, only three parameters would be needed to adjust these three EVs to any SNe II light-curve:

$$LC(t)=\sum_{i=0}^{3} A_i \times EV_i(t)$$

Outlook



We presented here the results only for the V band. Further analysis will be performed including other passbands.

The final goal of this work is to enable the use of SNe II as standard candles only with photometric information, and to produce a Hubble diagram for type II SNe.

We have compiled a sample of more than thousand spectroscopically confirmed and photometrically identified type II SNe, up to higher redshift. This sample will be analyzed using the same procedure.

Support for LG is provided by the Ministry of Economy, Development, and Tourism's Millennium Science Initiative through grant IC12009, awarded to The Millennium Institute of Astrophysics, MAS. LG acknowledges support by CONICYT through FONDECYT grant 3140566