

SDSS-II/SNLS3 Joint Light-curve Analysis

Table of Contents

1. Release history
 - V1 (January 2014, paper submitted):
 - V2 (March 2014):
 - V3 (April 2014, paper accepted):
 - V4 (June 2014):
 - V5 (March 2015):
 - V6 (March 2015):
2. Installation of the C++ likelihood code
 - Installation of the cosmomc plugin
3. SALT2 model
4. Error propagation
 - Error decomposition
 - SALT2 light-curve model uncertainties
5. Recalibrated light-curves in native SALT2 format
6. Presentation material

This page contains links to data associated with the SDSS-II/SNLS3 Joint Light-Curve Analysis (Betoule et al. 2014, submitted to A&A).

The release consists in:

1. The end products of the analysis and a C++ code to compute the likelihood of this data associated to a cosmological model. The code enables both evaluations of the *complete* likelihood, and *fast* evaluations of an *approximate* likelihood (see Betoule et al. 2014, Appendix E).
2. The version 2.4 of the SALT2 light-curve model used for the analysis plus 200 random realizations usable for the propagation of model uncertainties.
3. The exact set of Supernovae light-curves used in the analysis.

We also deliver presentation material.

Since March 2014, the JLA likelihood plugin is included in the official release of cosmomc. For older versions, the plugin is still available (see below: *Installation of the cosmomc plugin*).

To analyze the JLA sample with SNANA, see `$SNDATA_ROOT/sample_input_files/JLA2014/AAA_README`.

1 Release history

V1 (January 2014, paper submitted):

First arxiv version.

V2 (March 2014):

Same as v1 with additionnal information (R.A., Dec. and bias correction) in the file of light-curve parameters.

V3 (April 2014, paper accepted):

Same as v2 with the addition of a C++ likelihood code in an independant archive (jla_likelihood_v3.tgz).

V4 (June 2014):

Second arxiv version:

- Add the compressed version of the JLA likelihood (see Betoule et al. 2014, Appendix E)
- Make the C++ likelihood code (jla_likelihood_v4.tgz) the main product.

V5 (March 2015):

Correction of the *C_stat.fits* matrix (from archive file covmat_v4.tgz).

Previous to this release, the matrix contained in *C_stat.fits* was not the covariance matrix of light-curve parameters but a modified matrix, which, in particular was not positive. Off-diagonal entries of the (C_{stat}) matrix had been symetrized, the way the cosmomc plugin expect covariances between 2 different parameters to be given (as in the data/jla*_covmatrix.dat files). As an exemple, the entry corresponding to $(cov(x_{1i}, c_j))$ with $(i \neq j)$ contained instead $(0.5 \left[cov(x_{1i}, c_j) + cov(x_{1j}, c_i) \right])$.

It is important to note that this has no impact on the computation of the covariance of distance moduli and thus no impact in cosmological fits because both terms indeed play symmetric roles there.

V6 (March 2015):

Change the presentation of the covmat tarball (see *Error decomposition* below) to match the presentation of uncertainties given in the paper.

2 Installation of the C++ likelihood code

The JLA C++ code and data are available from a single archive: `jla_likelihood_v6.tgz`. The code prerequisites working implementation of LAPACK and BLAS. To compile the static library edit the provided makefile to suit your local environment and do:

```
make
```

You may also need to adapt the name of lapack routines in `jla.cc` to match the convention of your fortran compiler.

The compilation of the provided example test depends on the CLASS CMB code for background computation. To compile this example fill the makefile with the path to your local class installation and type:

```
make test_jla
```

Running this test should perform an evaluation of both the *complete* and *approximate* JLA χ^2 for the best-fit Λ CDM model. The expected result is approximately $\chi^2 = -2 \log L = 682.9$ for the complete likelihood and $\chi^2 = -2 \log L = 33.62$ for the compressed approximate likelihood.

Light-curve parameters are given in file `data/jla_lcparams.txt`. The columns are:

```

name: name of the SN
zcmb: CMB frame redshift (including peculiar velocity corrections for
      nearby supernova based on the models of M.J. Hudson)
zhel: Heliocentric redshift (note both zcmb and zhel are needed
      to compute the luminosity distance)
dz: redshift error (no longer used by the plugin)
mb: B band peak magnitude
dmb: Error in mb (includes contributions from intrinsic dispersion,
      lensing, and redshift uncertainty)
x1: SALT2 shape parameter
dx1: Error in shape parameter
colour: Colour parameter
dcolour: Error in colour
3rdvar: In these files, the log10 host stellar mass
d3rdvar: Error in 3rdvar
tmax: Date of peak brightness (mjd)
dtmax: Error in tmax
cov_m_s: The covariance between mb and x1
cov_m_c: The covariance between mb and colour
cov_s_c: The covariance between x1 and colour
set: A number indicating which sample this SN belongs to, with
      1 - SNLS, 2 - SDSS, 3 - low-z, 4 - Riess HST
ra: Right Ascension in degree (J2000)
dec: Declination in degree (J2000)
biascor: The correction for analysis bias applied to measured magnitudes
          (this correction is already applied to mb, original measurements
          can be obtained by subtracting this term to mb)

```

Installation of the cosmomc plugin

Since March 2014, the JLA likelihood plugin is included in the official release of cosmomc. For older cosmomc versions, the original plugin is still available: `jla_cosmo_v2.tgz`.

Untar the archive and copy the following files to the corresponding cosmomc directory:

- `source/supernovae_JLA.f90`
- `data/jla.dataset`
- `data/JLA.paramnames`

- data/jla_*

Add the JLA likelihood in source/supernovae.f90:

```
use JLA
...
call JLALikelihood_Add(LikeList, Ini)
```

Modify the "SUPERNOVAE =" line of the cosmomc source/Makefile line to compile the JLA likelihood:

```
SUPERNOVAE = supernovae_Union2.o supernovae_SNLS.o supernovae_JLA.o
```

Depending on your cosmomc installation, you may obtain the same result by extracting directly the archive in your cosmomc directory.

3 SALT2 model

Version 2.4 of the SALT2 code, is available from the SALT2 home page. The corresponding data, including the model trained on the JLA training sample, and the description of instruments involved in the cosmology sample can be downloaded here: [salt2-4_data.tgz](#) (md5:af829c7f177c6037adcbe0a89360464a).

With this model, the fit of the lightcurves of SNLS 03D4ag (see *Recalibrated light-curves in native SALT2 format*) should return:

```
BEGIN_OF_FITPARAMS Salt2Model
DayMax 52830.9312582 0.0955792582608
Redshift 0.285 0 F
Color -0.0851965244364 0.0234763445429
X0 5.65786629794e-05 1.52744999131e-06
X1 0.937399343815 0.104657850633
RestFrameMag_0_B 21.2581394711 0.0292572971214
CovColorColor 0.000551138753097 -1
CovColorDayMax -0.00012040087613 -1
CovColorRestFrameMag_0_B 0.000524478290388 -1
CovColorX0 -2.73917683701e-08 -1
CovColorX1 -0.000243030505277 -1
CovDayMaxDayMax 0.00913539460969 -1
CovDayMaxRestFrameMag_0_B 0.000131399790871 -1
CovDayMaxX0 -6.85109541277e-09 -1
CovDayMaxX1 0.00179671536042 -1
CovRestFrameMag_0_BX0 -4.46890539999e-08 -1
CovRestFrameMag_0_BX1 0.00100854829146 -1
CovX0X0 2.33310347595e-12 -1
CovX0X1 -5.26149351948e-08 -1
CovX1X1 0.0109532656992 -1
END_OF_FITPARAMS Salt2Model
```

Note: This value of msb is different from the value published in Betoule et al. 2014 by -0.0012 because of malmquist bias correction.

4 Error propagation

Error decomposition

We deliver separate covariances matrices following the decomposition of the error on light-curve parameters proposed in Betoule et al. 2014, Eq. 11. The ordering of the $(3 \times N_{\text{SN}} = 2220)$ vector of light-curve parameters is: $\vec{\eta} = (m^{\star}_1, \{X_1\}_1, C_1, \dots, m^{\star}_{N_{\text{SN}}}, \{X_1\}_{N_{\text{SN}}}, C_{N_{\text{SN}}})$. The covariance matrix of this vector can be assembled as: $C_{\vec{\eta}} = C_{\text{stat}} + C_{\text{cal}} + C_{\text{model}} + C_{\text{bias}} + C_{\text{host}} + C_{\text{dust}} + C_{\text{pecvel}} + C_{\text{nonIa}}$ with:

- C_{stat} : statistical uncertainty (including the statistical uncertainty of the SALT2 Model, but without (σ_{coh}) and (σ_{lens}) of Eq. 13)
- C_{cal} : calibration uncertainty
- C_{model} : systematic uncertainty on the model (See Mosher et al. 2014)
- C_{bias} : uncertainty on the bias correction
- C_{host} : uncertainty on the fonctionnal form of the luminosity-host mass relation.
- C_{dust} : uncertainty on the Milky Way dust column density
- C_{pecvel} : uncertainty on the peculiar velocity correction (Systematic only: does not include the (σ_z) term of Eq. 13.)
- C_{nonIa} : potential contamination by non-Ia.

Given the values of (α) and (β) parameters, the covariance matrix of distance moduli can be assembled following Eq. 13 of Betoule et al. (2014):

$$C = A C_{\vec{\eta}} A^T + \text{diag}\left(\frac{5\sigma_z}{z \log 10}\right)^2 + \text{diag}(\sigma_{\text{lens}}^2) + \text{diag}(\sigma_{\text{coh}}^2)$$

The $(3N_{\text{SN}} \times 3N_{\text{SN}} = 2220 \times 2220)$ matrices and the (σ_{coh}) and (σ_{lens}) vectors are provided in covmat_v6.tgz. A sample python script is provided to illustrate computation of C from the given products.

SALT2 light-curve model uncertainties

Photometric calibration uncertainties in the training data sample affect the recovered SALT2 model. The resulting error in turn affects coherently all the light-curve fitted with this model. We emphasize that *assuming a perfect calibration of the model when fitting for supernovae can result in a serious underestimation of the actual uncertainty*.

In order to enable the propagation of uncertainties associated with the use of the SALT2 model, we release a set of 200 random realizations of the model, drawn according to the estimate of calibration uncertainties affecting the JLA training sample:

To obtain an estimate of the covariance of fit parameters: A possibility is to fit a set of SNe light-curves with each random realization and estimate the covariance of

5 Recalibrated light-curves in native SALT2 format

Light curves of SN includes in the cosmology sample: `jla_light_curves.tgz` (md5:14f402041003661d284ac18dbcc7ec24).

It includes:

- the recalibrated SNLS3 light curve (`lc-??D???.list`)
- the recalibrated SDSS-II light-curves (`lc-SDSS*.list`, subsample of <http://sdssdp62.fnal.gov/sdsssn/DataRelease/index.html>)
- Nearby and HST light-curves from the C11 compilation (`lc-sn*.list` and `lc-name.list`, available from <https://tspace.library.utoronto.ca/snls/>)

Six SNe (`sn2005hc`, `sn2005ir`, `sn2006nz`, `sn2006oa`, `sn2006ob`, `sn2006on`) are in common with SDSS and either CfAIII or CSP. The light-curve file contains a merge of all available photometry.

6 Presentation material

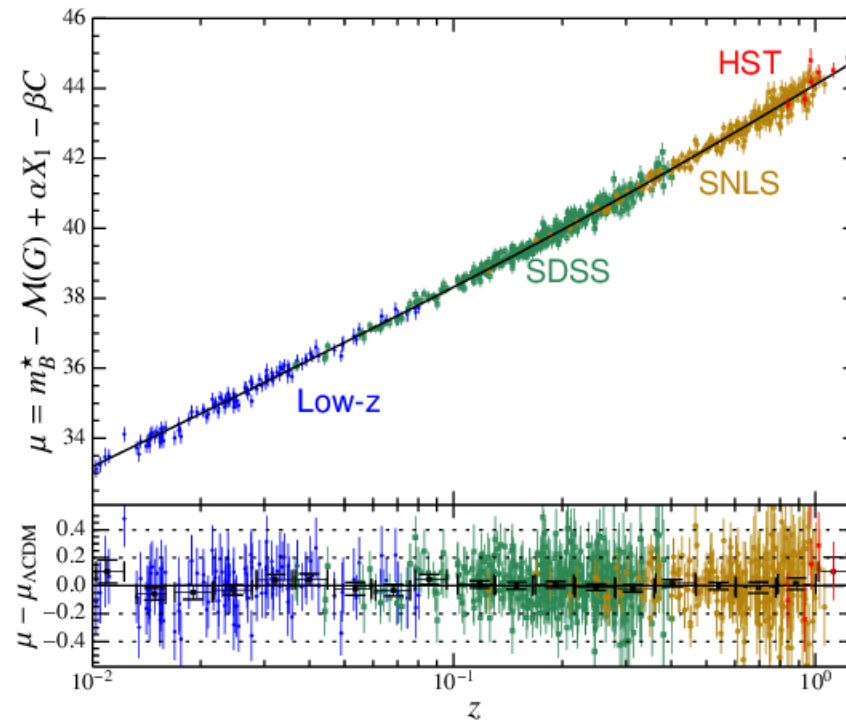


Figure 1: JLA Hubble diagram

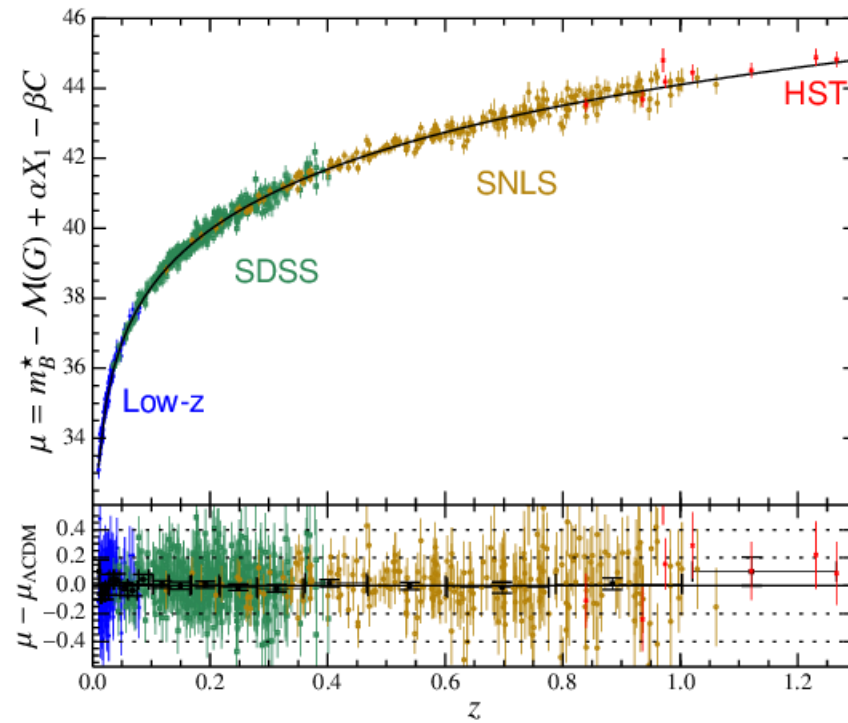


Figure 2: Alternative JLA Hubble diagram (linear x axis)

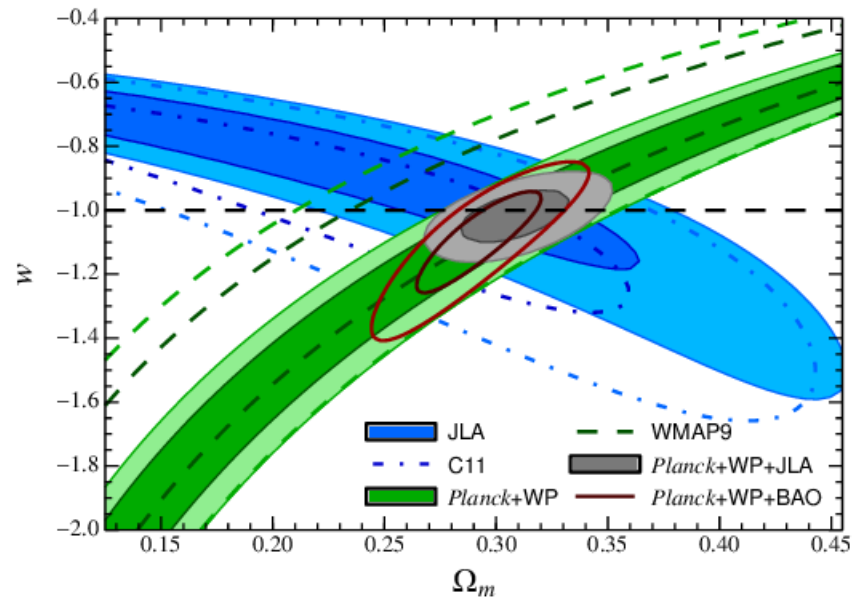
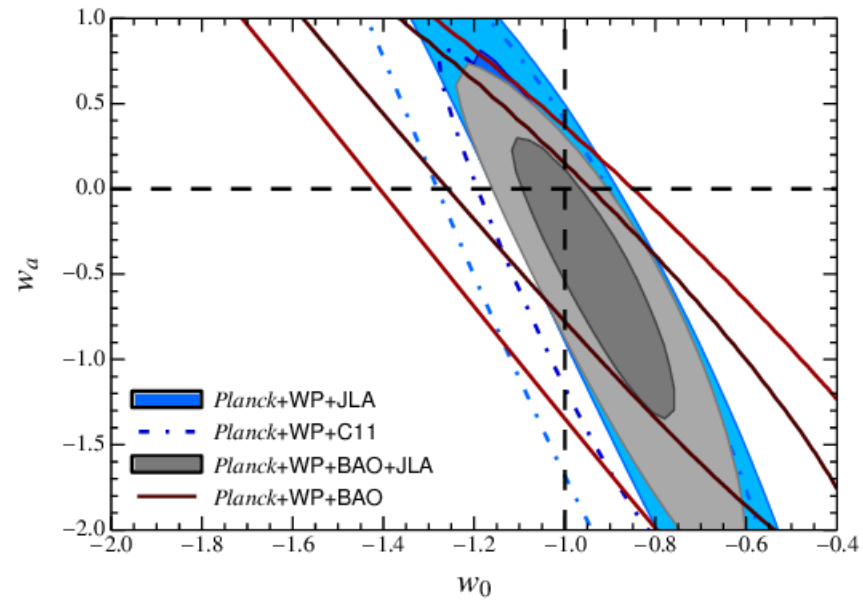


Figure 3: Flat w-CDM fit parameters

Figure 4: Flat w - z -CDM fit parameters

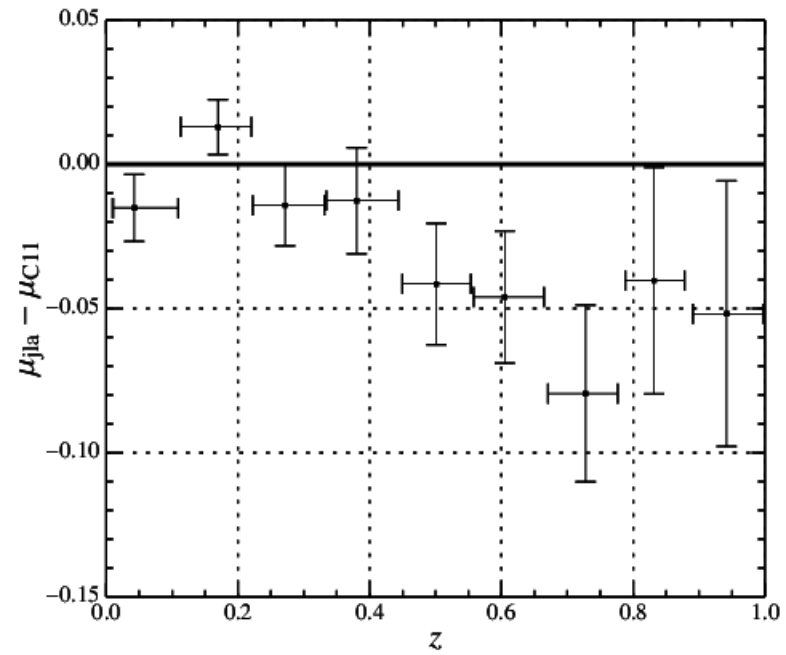


Figure 5: Difference in distance modulus between the JLA and Conley et al. (2011) hubble diagrams

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