Type Ia Supernova forecast with Zwicky Transient Facility phase III

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Introduction and basis

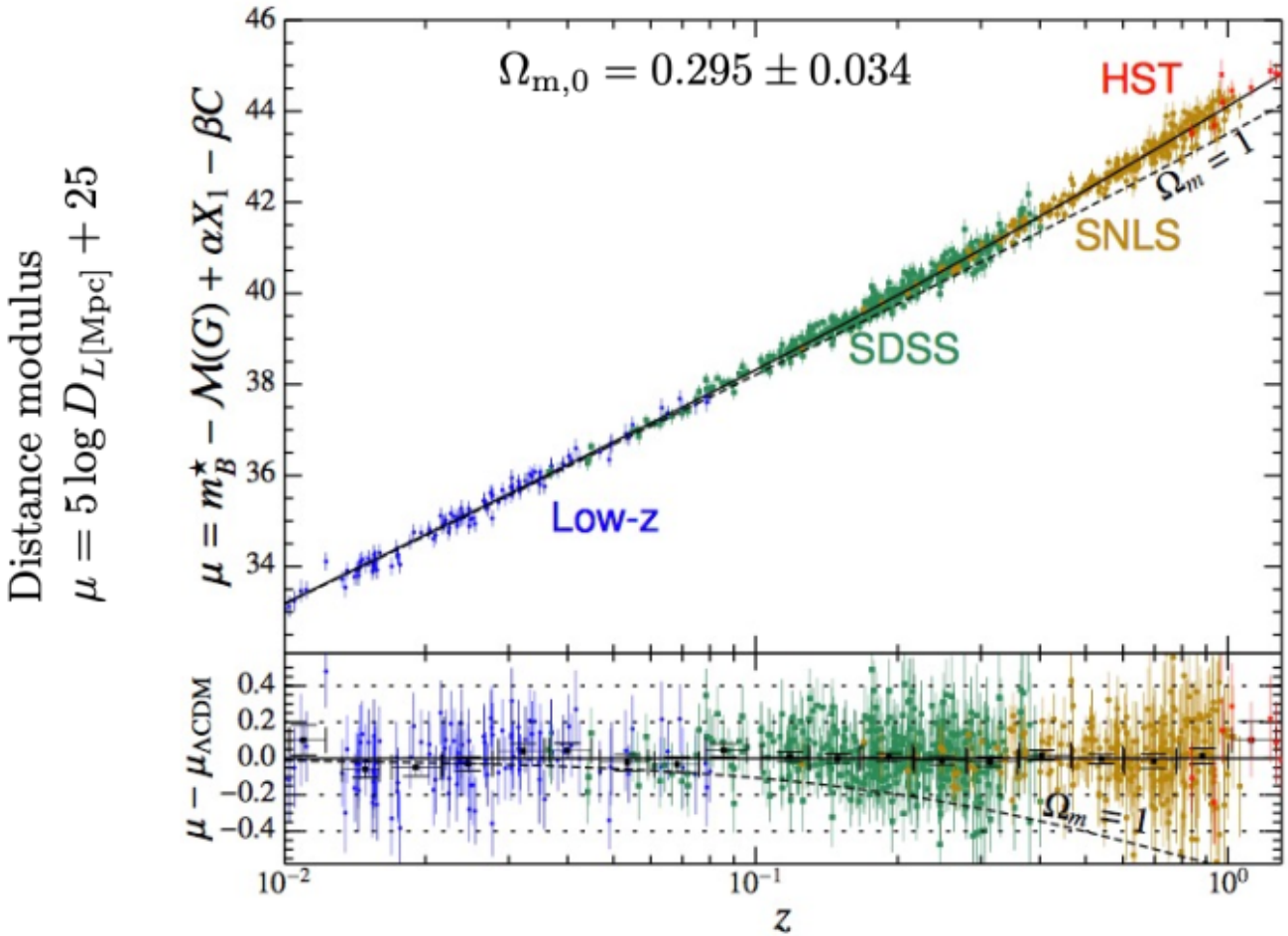
Type Ia supernova

- Supernova : a star exploding at the end of its life, the internal forces not managing the stop the collapse due to gravitational forces.
- Type Ia : not the end of life of a star, but a white dwarf exceeding the Chandrasekhar limit of $1.4 M_{\odot}$ by accretion of matter in a binary system. Since the limit is roughly the same : similar light curves.

Type Ia supernova

Perfect candidate to be a standard candle. We fit the light curve using SALT2 model and fitting the stretch parameter x_1 and the color parameter c:

$$\mu = m_B - M_B + \alpha x_1 - \beta c \tag{1}$$



What is ZTF

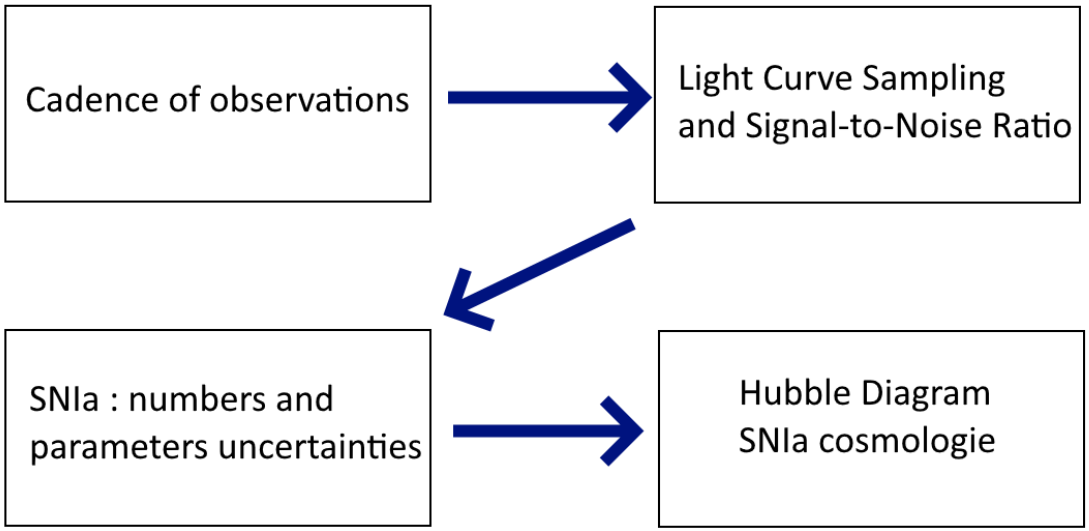
- Zwicky Transient Facility (ZTF)
- At the Mount Palomor, California USA.
- Search for Supernovae using a 1.2m telescope with a 36cmx36cm camera.

Actual observation parameters :

- Exposure time : 30s.
- 16 CCD : 605 Mpixels
- Filters : G, R, I.

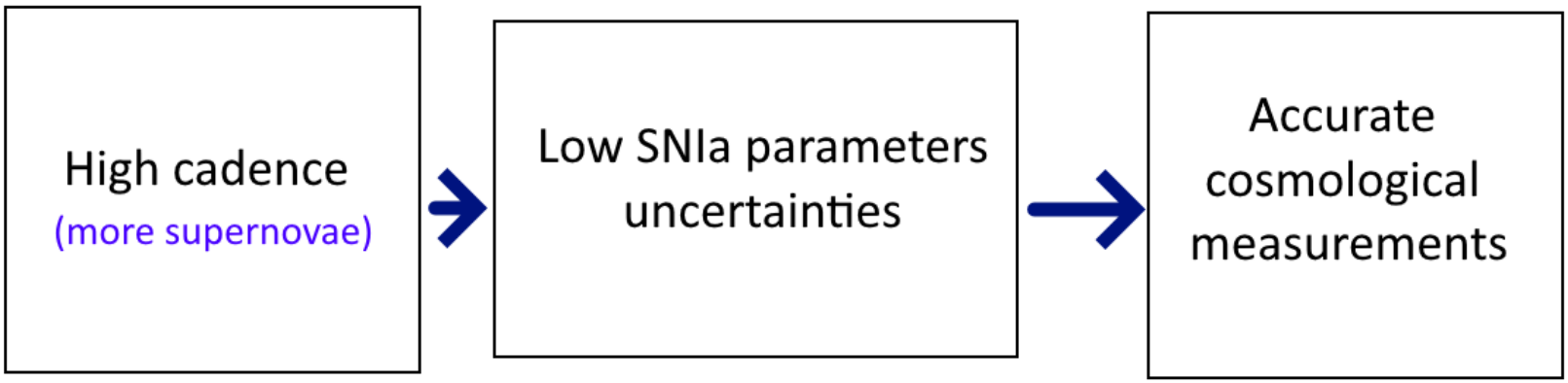
Cadence of observation

Large field of view
$\rightarrow$ Excellent cadence of observation
$\rightarrow$ Typical cadence : 1-2 nights to cover the sky with G, R bands, 10 % in I.



Cadence of observations

ZTF I (2018-2020)+ZTF II(2021-2024) $\rightarrow$ 6,000 well-measured Type Ia supernovae (SNe Ia) in the redshift range $0.01 \leq z \leq 0.1$.



Can we see at higher redshift, so $0.1 < z < 0.2$?

Internship and prospective advancement

Steps in the intership done at the time

I-Estimate the limiting magnitude (redshift completeness) of a ZTF III survey

- a. Define a set of observing strategies (cadence, number of visits per band,...)
- b. Simulations of SNe Ia light curve
- c. Light curve selection + SNe Ia parameters estimation

2. Impact on cosmology using a metric

- α. Implement the Fisher matrix method for uncertainties estimation.
- a. Simulate distance moduli from distributions extracted from previous research.
- b. Perform a cosmological fit $\rightarrow \Omega_m$.

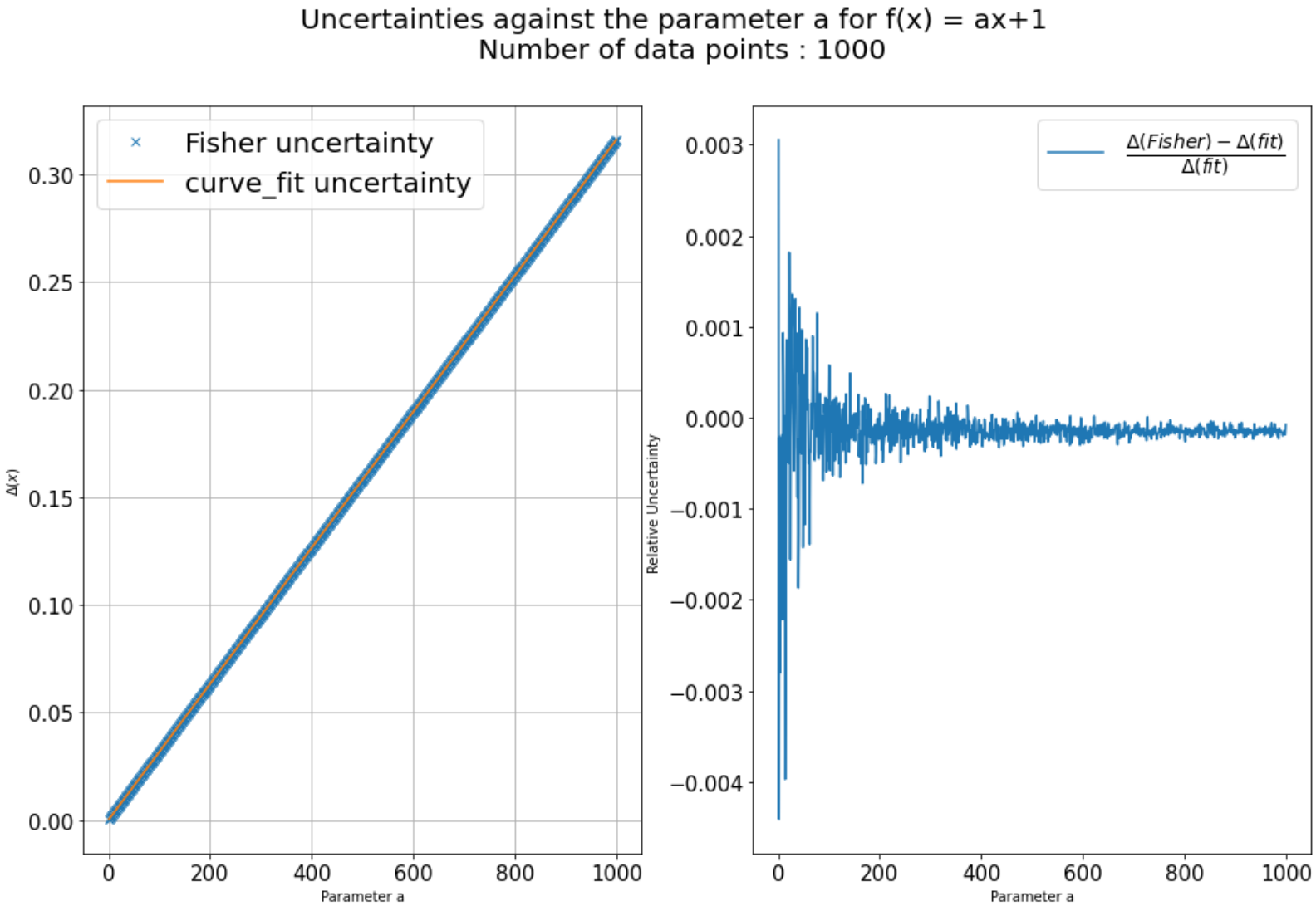
Fisher implementation

$$[F] = \frac{1}{2}\begin{bmatrix} \frac{\partial^2}{\partial x^2} & \frac{\partial^2}{\partial x \partial y} \\ \frac{\partial^2}{\partial x \partial y} & \frac{\partial^2}{\partial y^2} \end{bmatrix} \chi^2 \xrightarrow[inverse]{} [Covmatrix] \tag{2}$$

with χ^2 being :

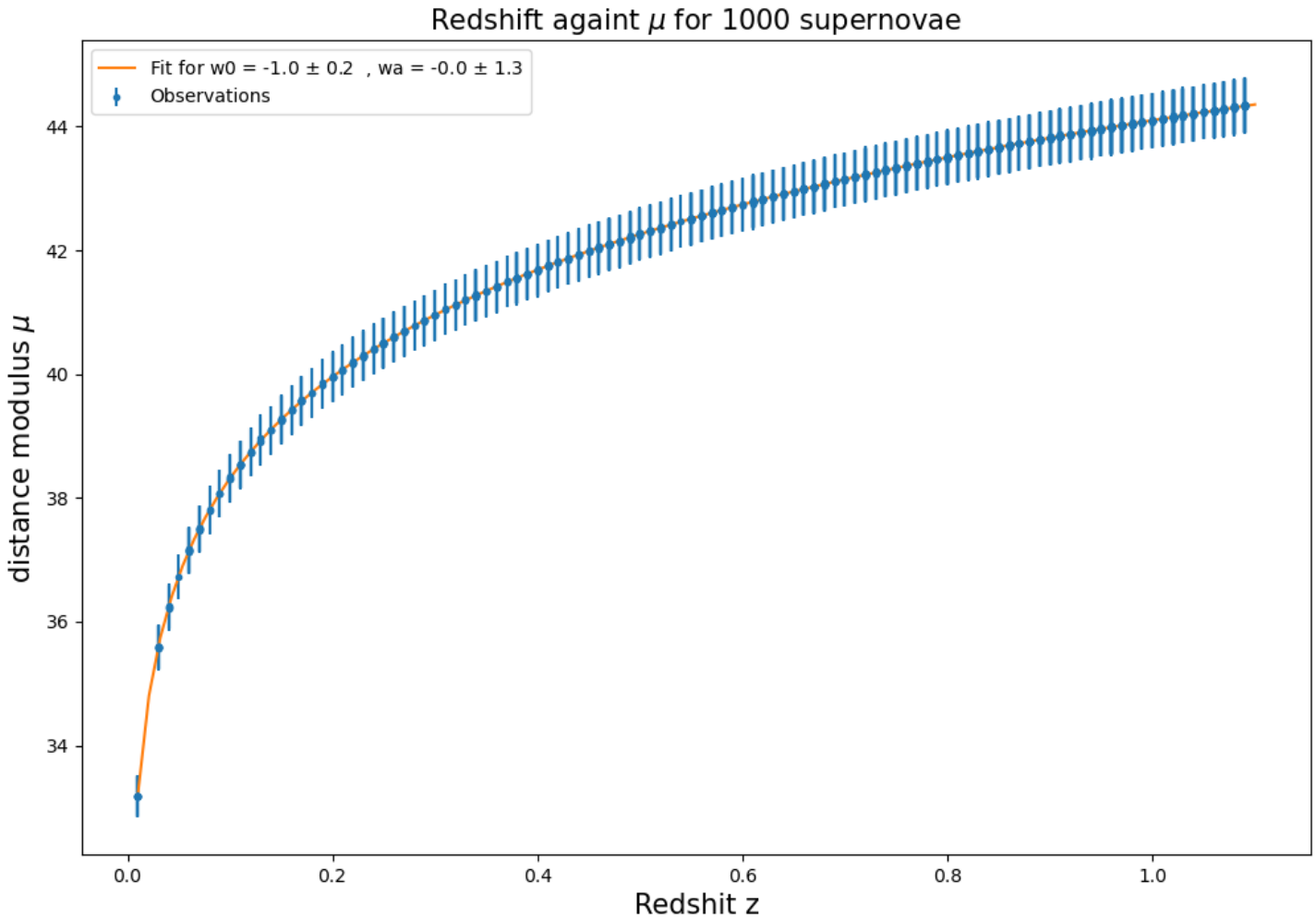
$$\chi^2 = \sum_i \frac{(y_i - f(x_i)^2}{\sigma_i^2} \tag{3}$$

Fisher implementation



Coherent generation of SNIa and fit

Perrett's rate : $r = (1+z)^{\alpha}$ where $\alpha = 2.11 \pm 0.28$



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Goals of this internship :

- Go into the simulations of SNIa and change the cadence.
- Estimate the maximum redshift completeness for a given cadence.
- Propose a cadence for a potential phase III of ZTF.

Backup

Steps in the intership

I-Estimate the limiting magnitude (redshift completeness) of a ZTF III survey

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2. Impact on cosmology using a metric

- a. Simulate distance moduli from distributions extracted from previous research.
- b. Perform a cosmological fit $\rightarrow \Omega_m$