



Search for lensed supernovae by massive galaxy clusters with the 2.5m Nordic Optical Telescope

A. Goobar,
R. Amanullah,
J. Johansson,

Tanja Petrushevskaja

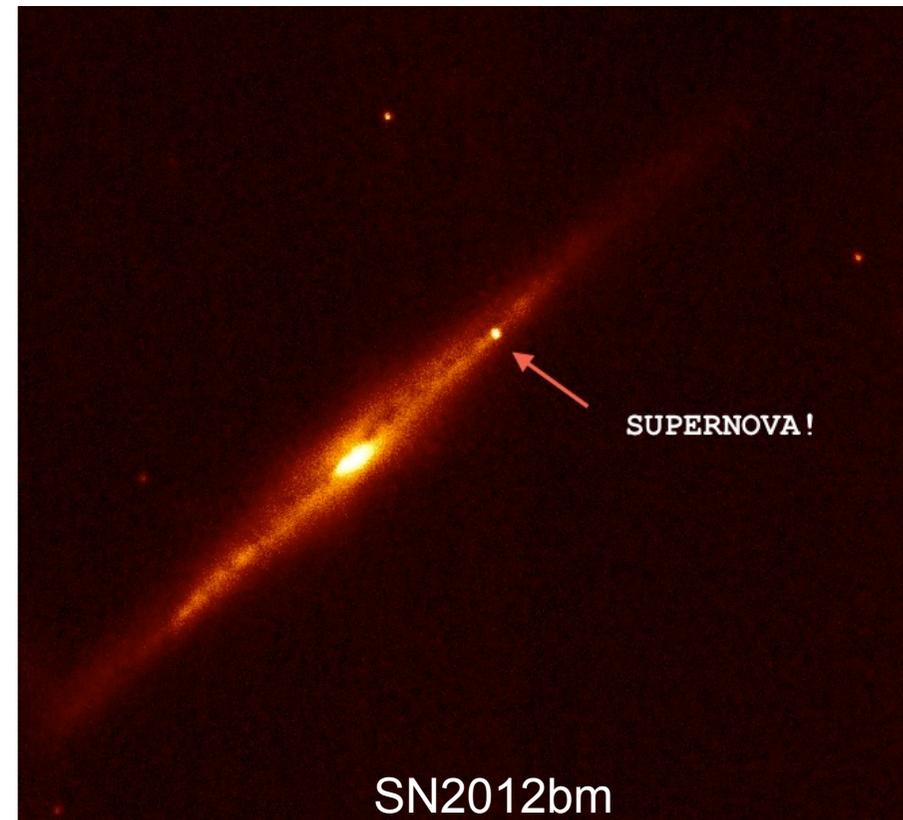
tanja.petrushevskaja@fysik.su.se

FUTURE SCIENCE WITH METRE-CLASS TELESCOPES

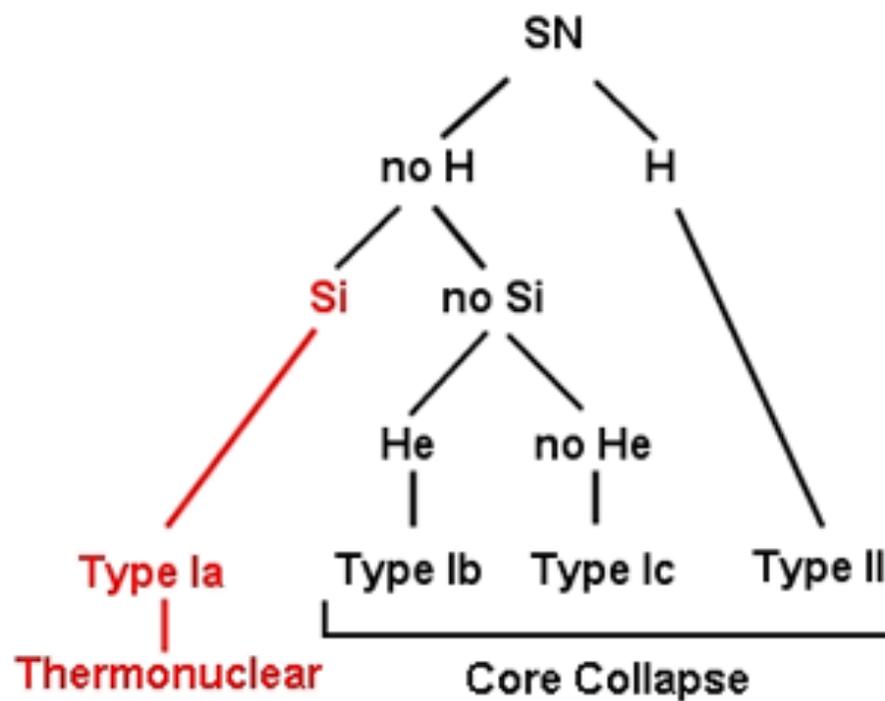
18-21 SEPTEMBER 2012 -- BELGRADE, SERBIA

Why supernovae?

- Exploding stars at the end of their life cycles, one of the most energetic phenomena in the Universe
 - -> Very useful for cosmology and astrophysics

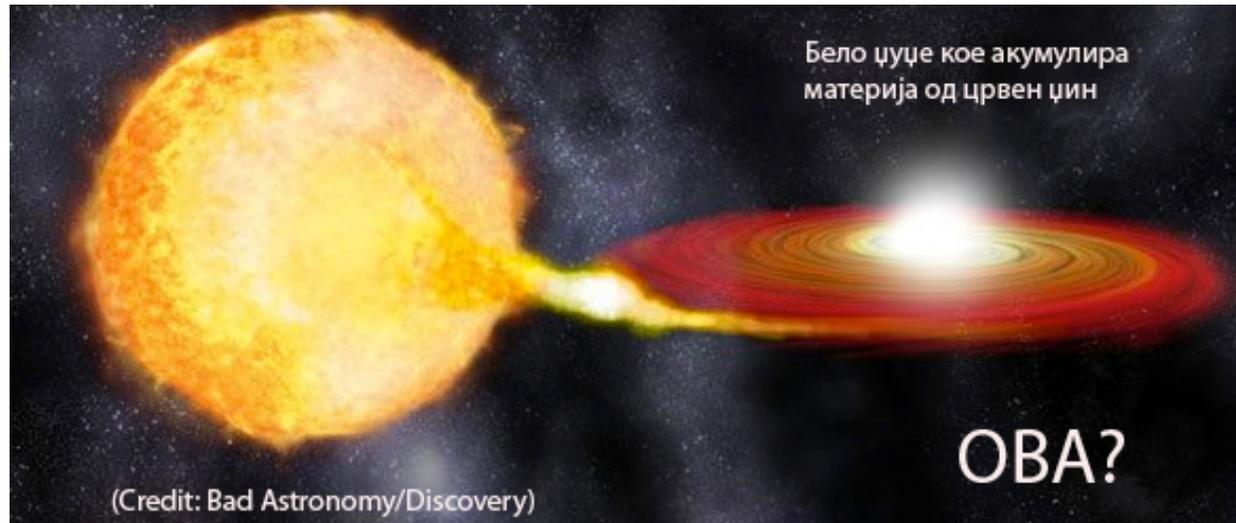


Classification of supernovae

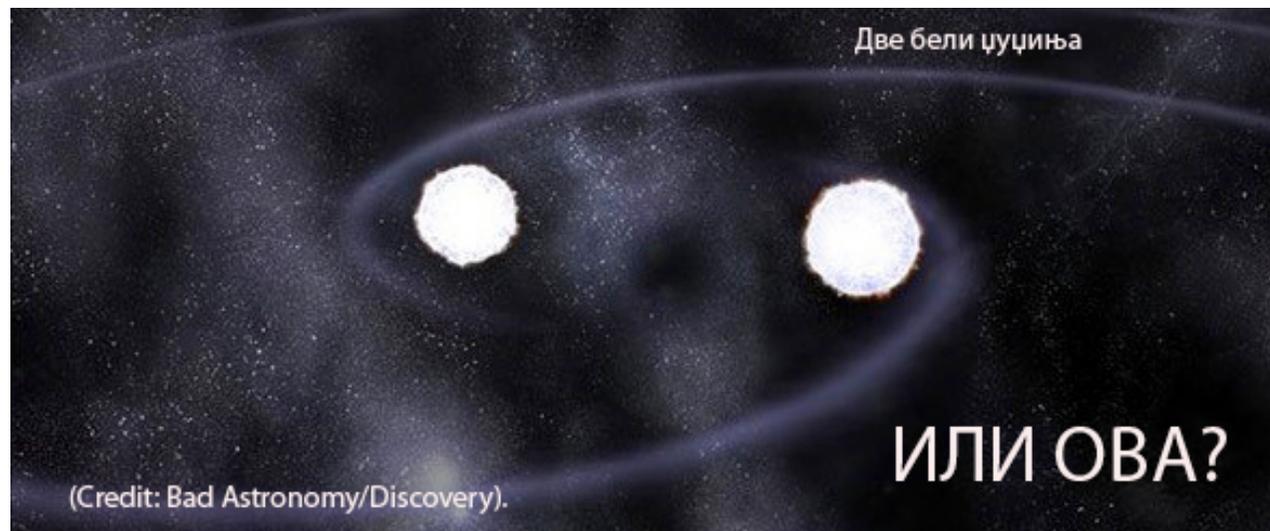


6150 Å

Progenitor scenario for SN Ia



Important to have
SN with $z > 1.2$ where
the predicted SNIa
rate is most sensitive
to the delay time



19/09/12

Tanja Petrushevsk
tanja.petrushevsk@fysik.su.se

Measuring distances-> cosmological parameters

Luminosity distance
(flat geometry and a non-zero Dark Energy
density that is not necessarily the same as Einstein's
cosmological constant is:

$$D_l(z) = c \frac{(1+z)}{H_0} \int_0^{z_e} \frac{dz'}{\sqrt{\Omega_M (1+z')^3 + \Omega_\Lambda (1+z')^{3(1+w)}}$$

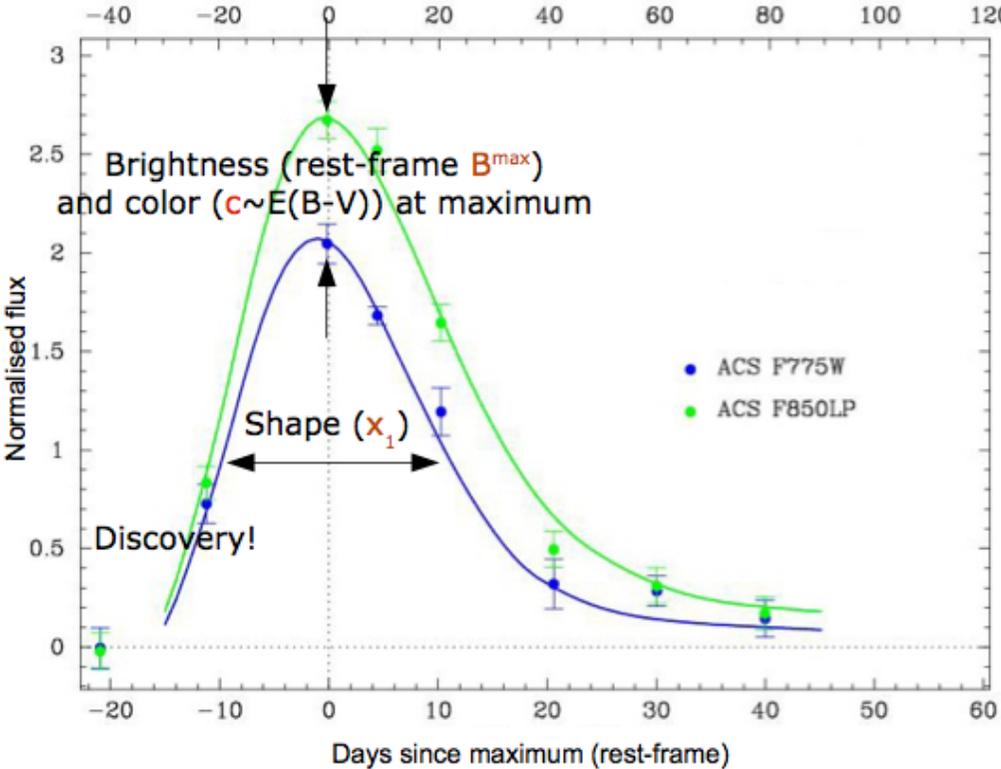
Here $w = P / (\rho c^2)$ is the equation of state parameter.
If $w = -1$, then the Dark Energy is equivalent to
Einstein's cosmological constant.



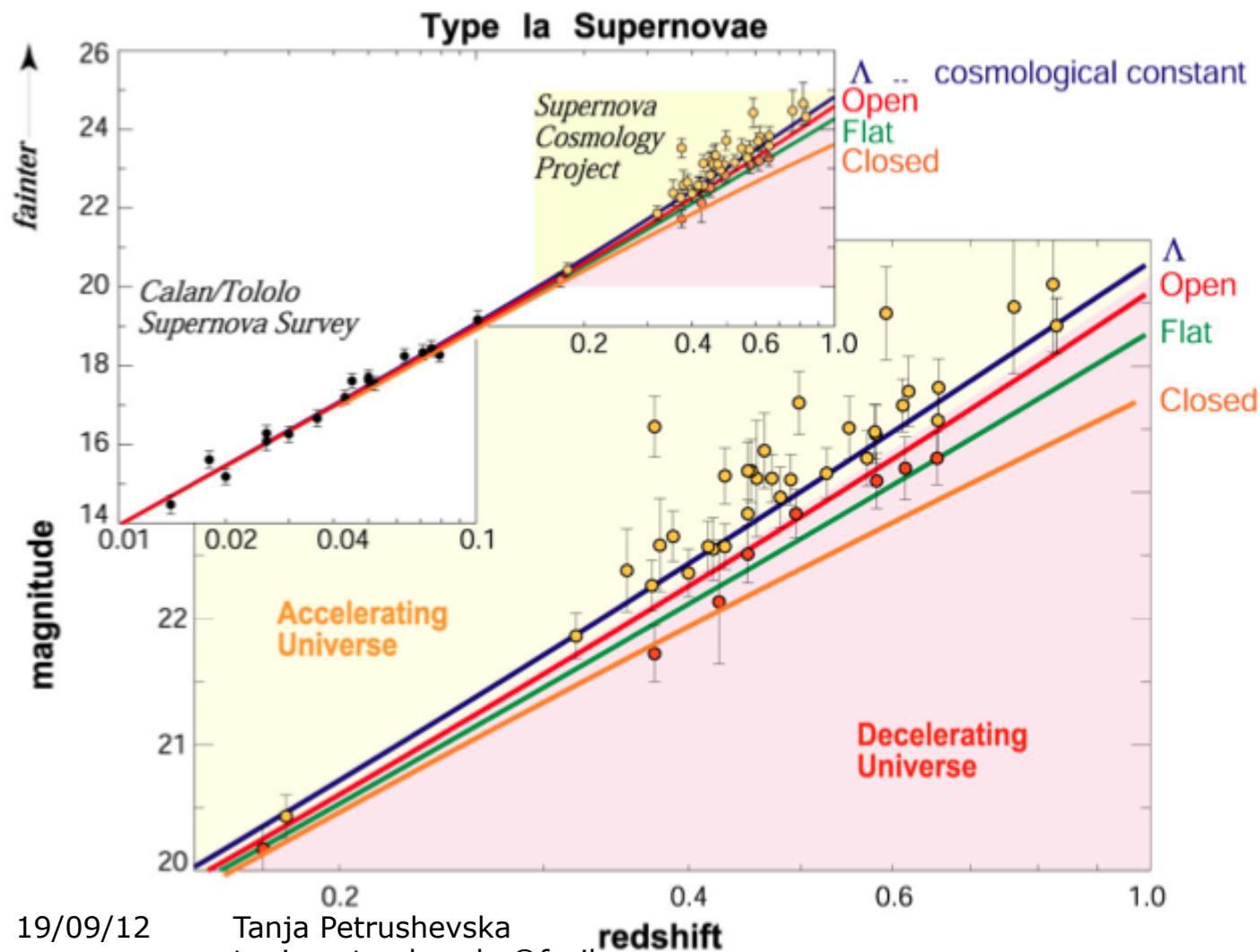
SNe Ia are standard candles...

SN distance modulus
Cosmology

$$B^{\max} - \beta \cdot c + \alpha \cdot x_1 - M_B = 5 \log_{10} d_L (\Omega_M, \Omega_X, w; z)$$



1998: Λ is not zero!



19/09/12

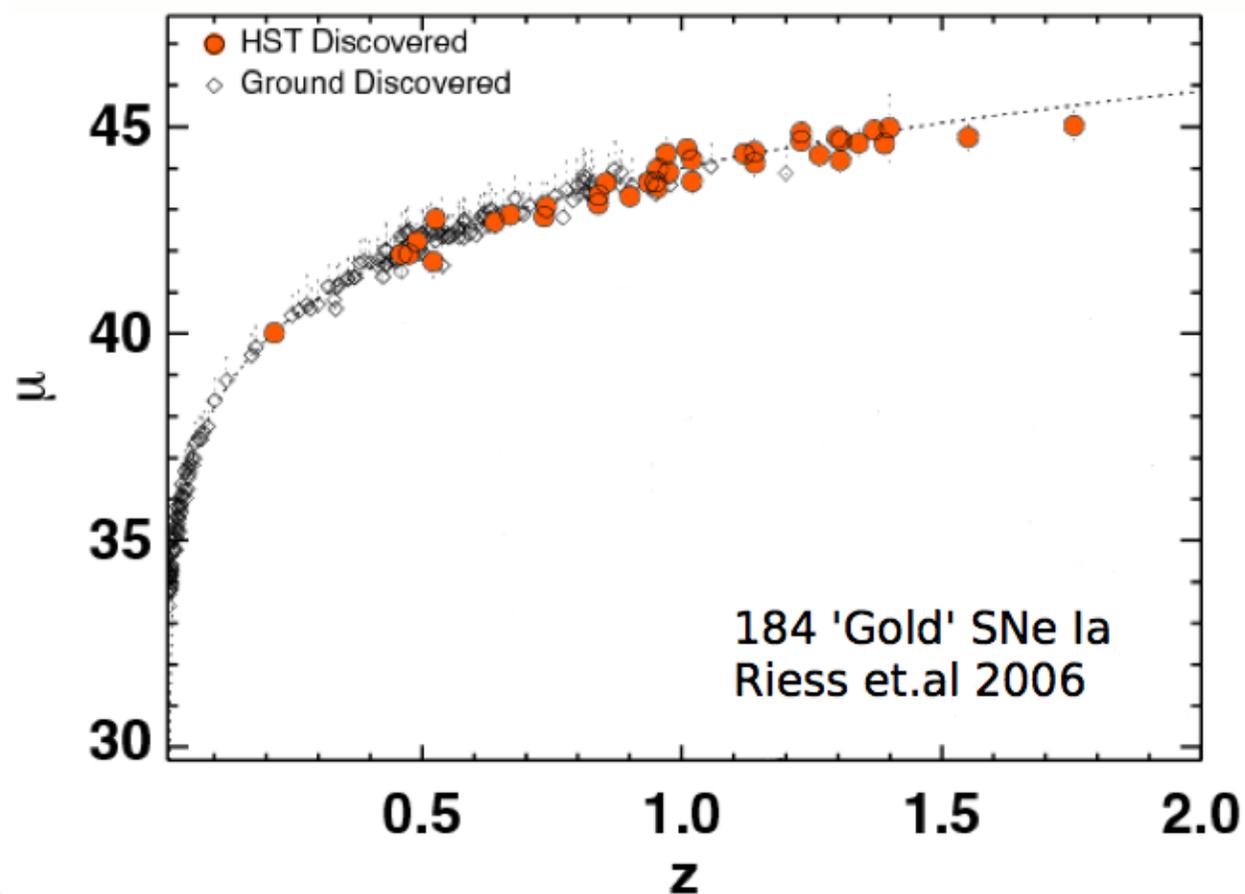
Tanja Petrushevska
 tanja.petrushevska@fysik.su.se

Nobel prize is physics 2011



"for the discovery of the accelerating expansion of the Universe through observations of distant supernovae"

Few events at $z > 1$...



The challenge of SN Ia cosmology

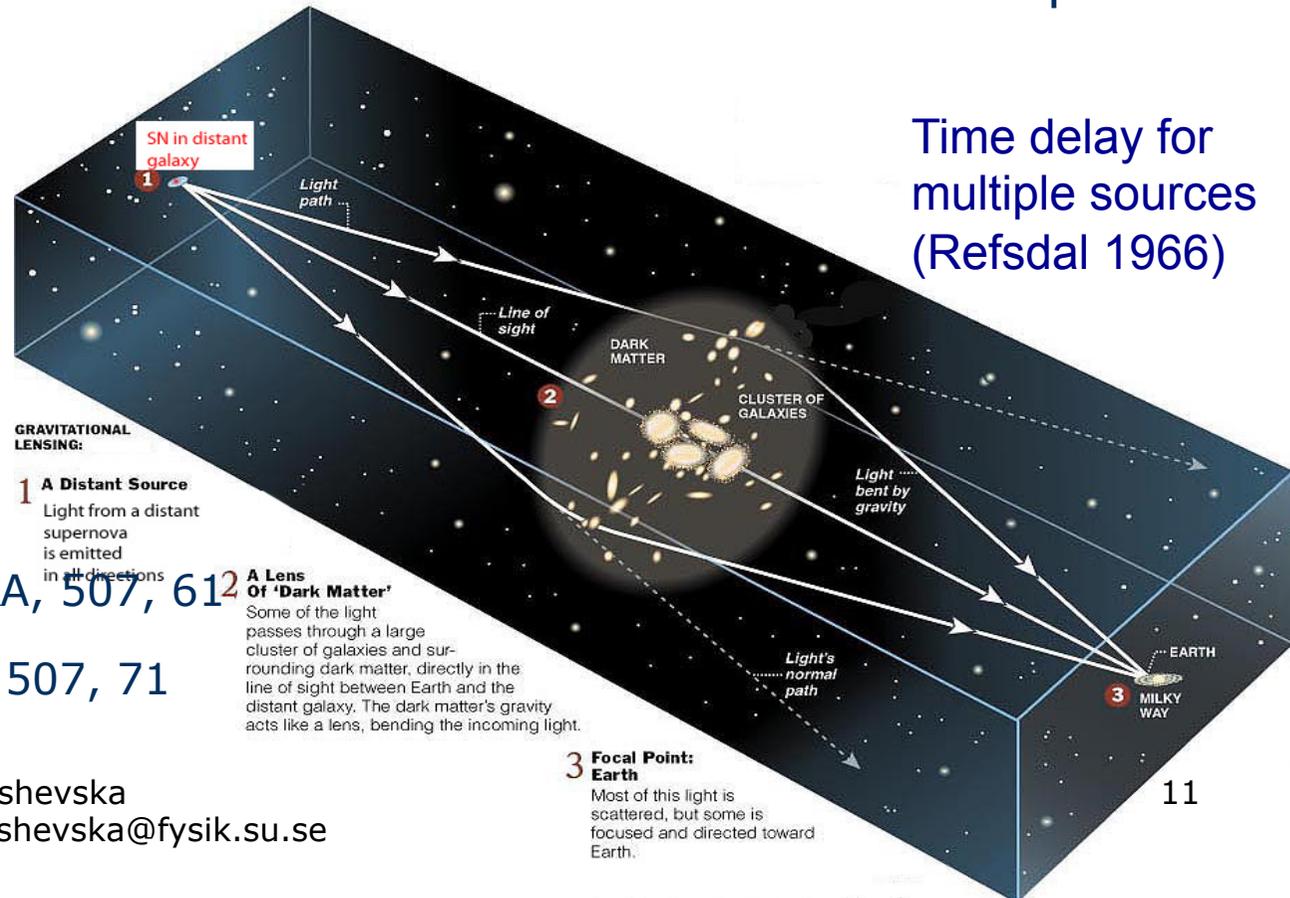
- ① Improve SNe Ia as standard candles
- ② Extend observations to higher redshifts
- ③ Reduce systematic errors

Using massive galaxy clusters as natural telescopes

- High-z with line-of-sight close to the core of the most massive galaxy clusters are gravitationally lensed by several magnitudes, putting supernovae at $z > 1.2$ within the reach of Nordic Optical Telescope

Improve the constrain on the cluster mass model

Time delay for multiple sources (Refsdal 1966)



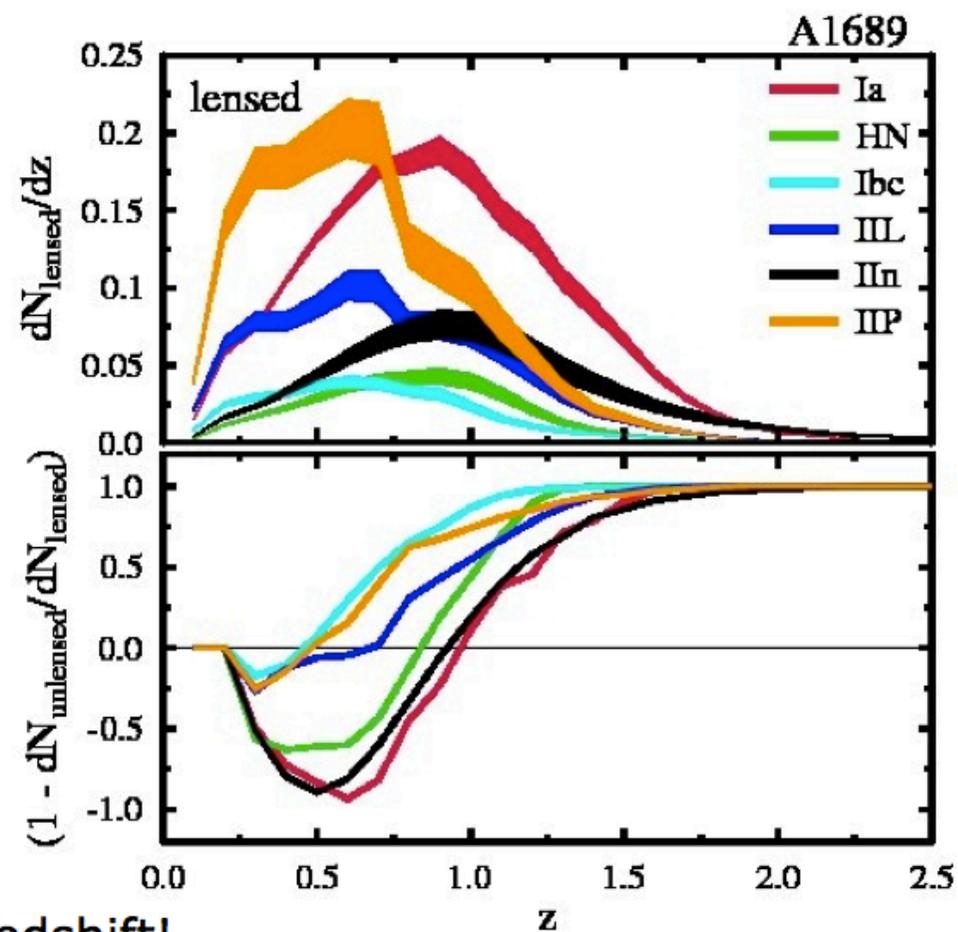
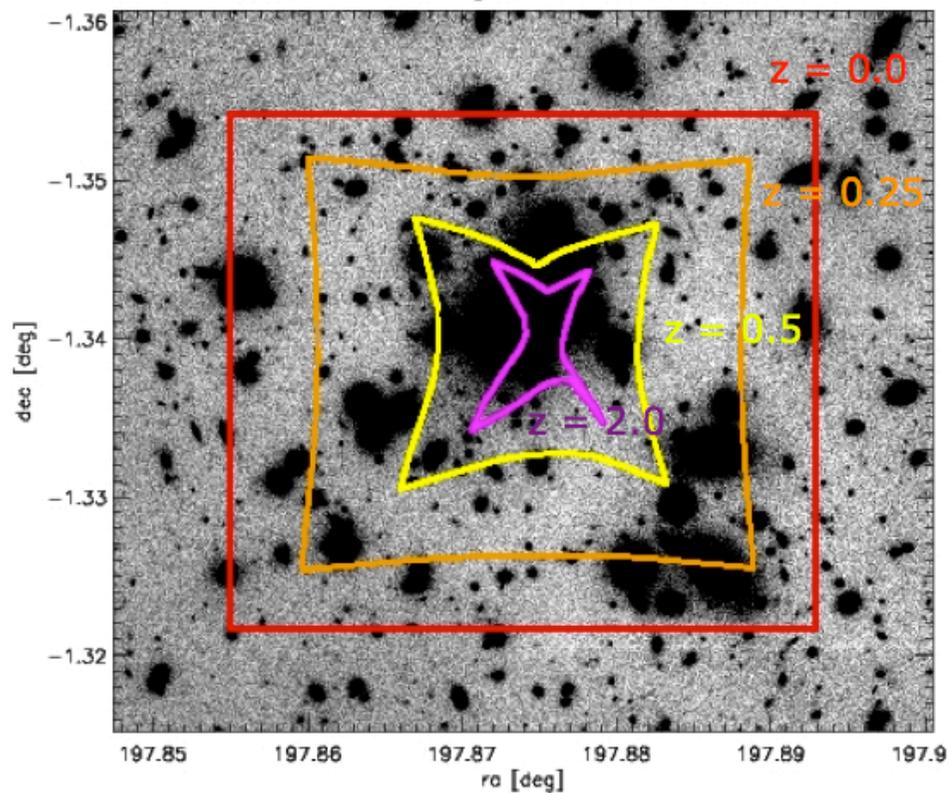
Stanishev et al., 2009, A&A, 507, 612

Goobar et al., 2009, A&A, 507, 71

19/09/12

Tanja Petrushevska
tanja.petrushevska@fysik.su.se

Source plane area for A1689



Less source area covered at high redshift!

2009 VLT ISAAC pilot survey



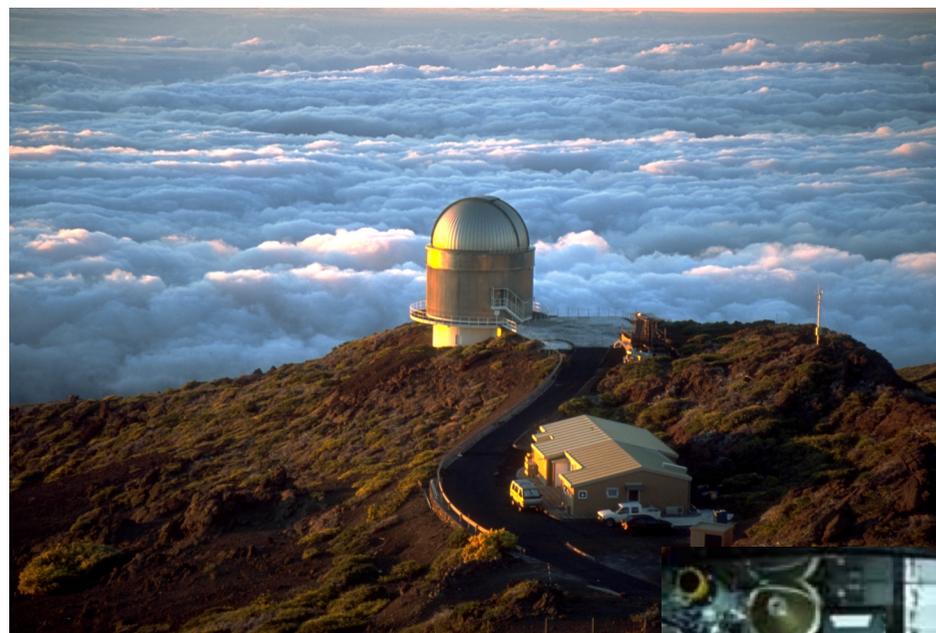
**Core collapse SN at $z = 1.703$
behind Abell 1689**

$$\Delta m_{\text{lens}} = 1.58 \pm 0.07 \text{ mag}$$

Amanullah R. et al (2011)

Monthly NOT search

- 2.5 m Nordic Optical Telescope at La Palma, Canaries
 - MOSaic Camera 4 chip CCD (2011)
 - ALFOSC (ongoing survey)
- VLT High Acuity Wide field K-band Imager – HAWK-I (archival data 2009)
- SUBARU (2013?)

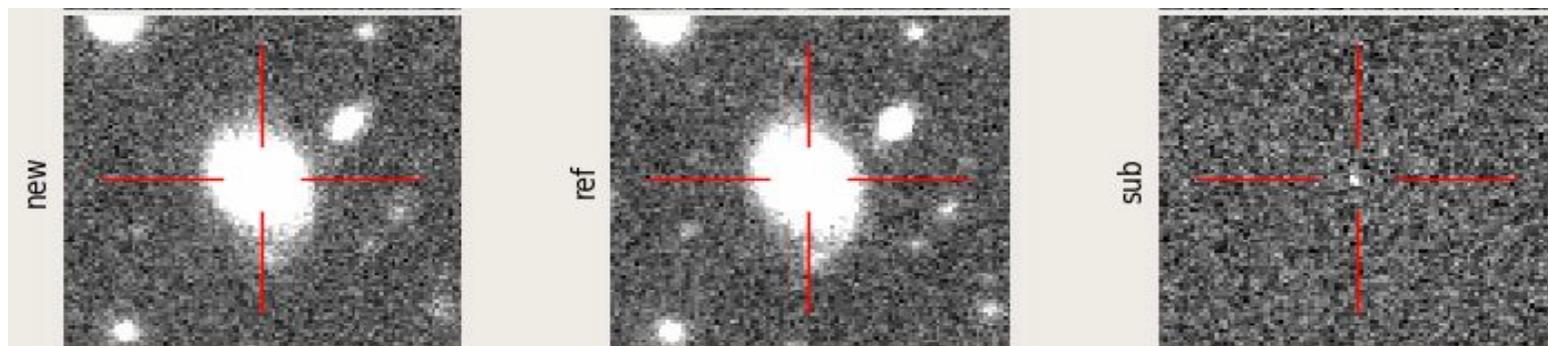


19/09/12

Tanja Petrushevskaja
tanja.petrushevskaja@fysik.su.se

Searching for candidates

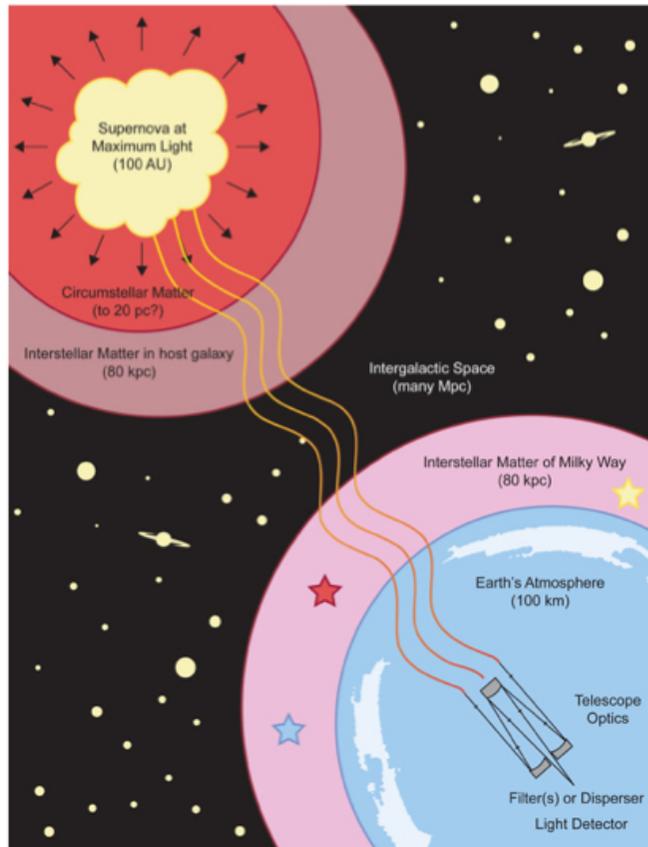
- Monthly follow up program (A1689, A1703, A1835, A2219, A2218, A2261, MACSJ1720+3536, SDSSJ1343+4155)
- Reduced -> Aligned -> Stacked -> Subtracted -> Looking for candidates
- Photometric calibration with SDSS catalog
- Detection efficiency
- Next step: building lightcurves for the candidates



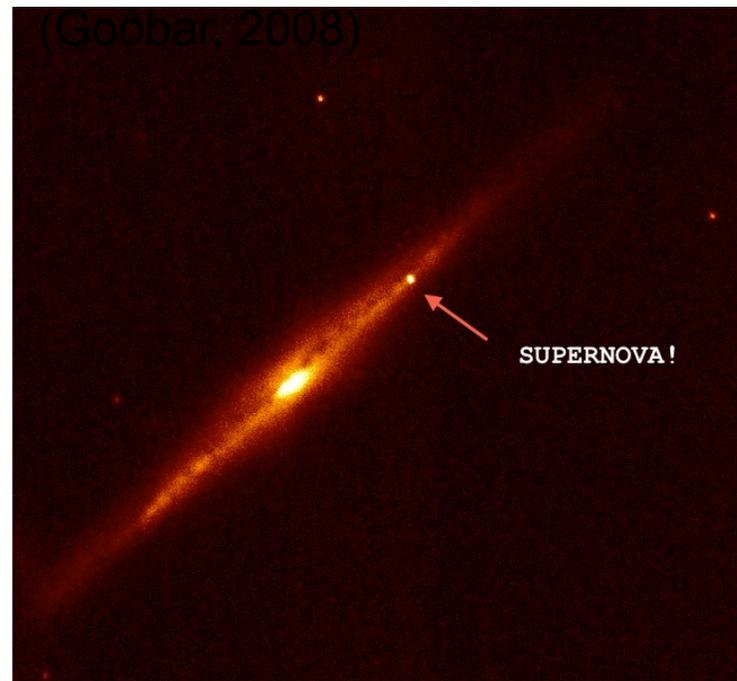
Bonus slide

Approved proposal at NOT Nearby SN search for circumstellar dust

– Study SN Ia observed with our HST programs



Could circumstellar dust explain SN Ia colours?



19/09/12

Tanja Petrushevskaja
tanja.petrushevskaja@fysik.su.se

16



Thank you

Хвала

FUTURE SCIENCE WITH METRE-CLASS TELESCOPES

18-21 SEPTEMBER 2012 -- BELGRADE, SERBIA