Investigating dust extinction using background quasars

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Some important parameters

- Extinction in the V-band A_V
- Colour excess

$$E(B-V) = (B-V)_{obs} - (B-V)_{intr}$$

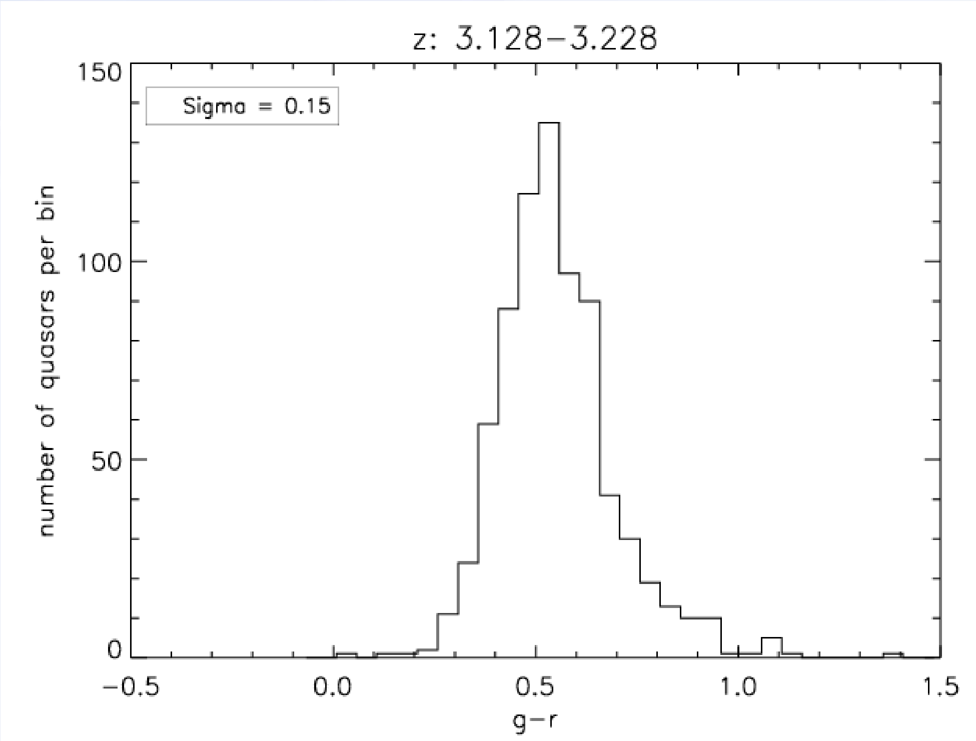
- Total-to-selective extinction ratio

$$R_V \equiv \frac{A_V}{E(B-V)}$$

Idea

- Dust extinction affects the colour differently depending on R_V and E(B-V)

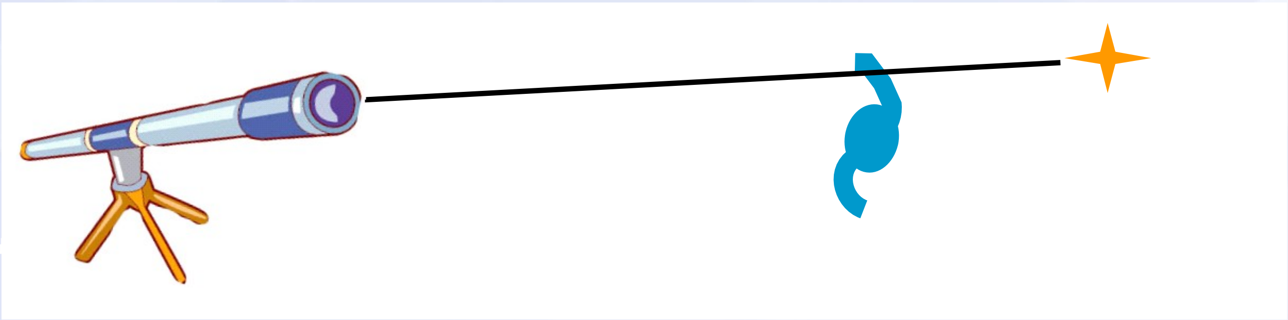
- Knowing the intrinsic colour, we can constrain the dust extinction
- Quasars have fairly homogeneous colours



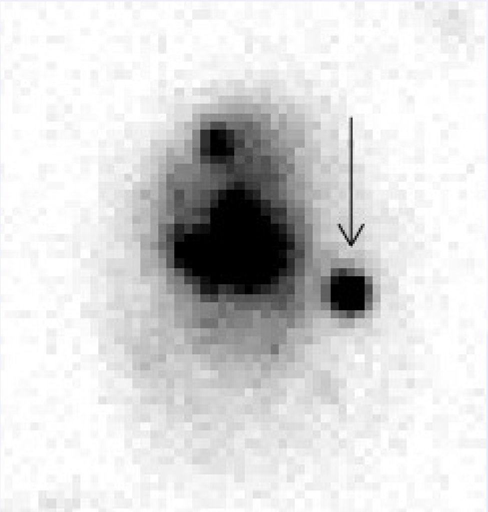
Method

- Identify quasars with the line-of-sight passing through the dust content of a galaxy
- To a quasar spectral template, we add dust extinction [with different R_V and E(B-V)] at the galaxy redshift and compute the resulting colours
- By comparing these simulated colours with the observed colours we learn about the properties of the dust extinction.
- Requirements: z (galaxy, quasar), photometry of the quasar

Finding pairs



- Coordinate matching
- Lensing
- Spectral identification



Choice of colours to compare

1) No redundant comparisons

2) Maximise the probability to detect dust extinction

3) Minimise the use of the photometry with large uncertainties

Maximising $$Q = \sum \frac{\left[E\left(i - j\right)\right]^2}{\sigma_{ij}^2}$$

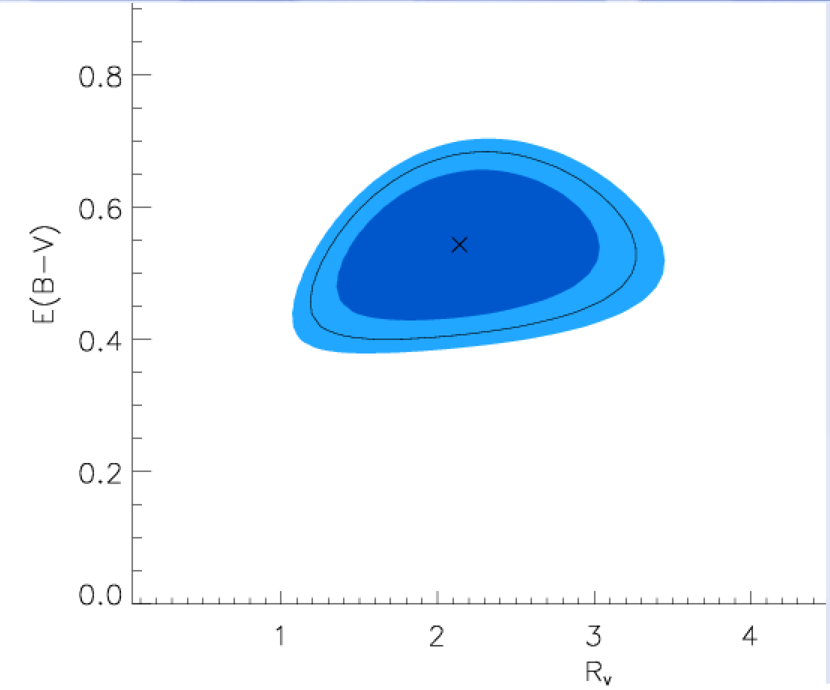
e.g. i,j = u,g,r,i,z

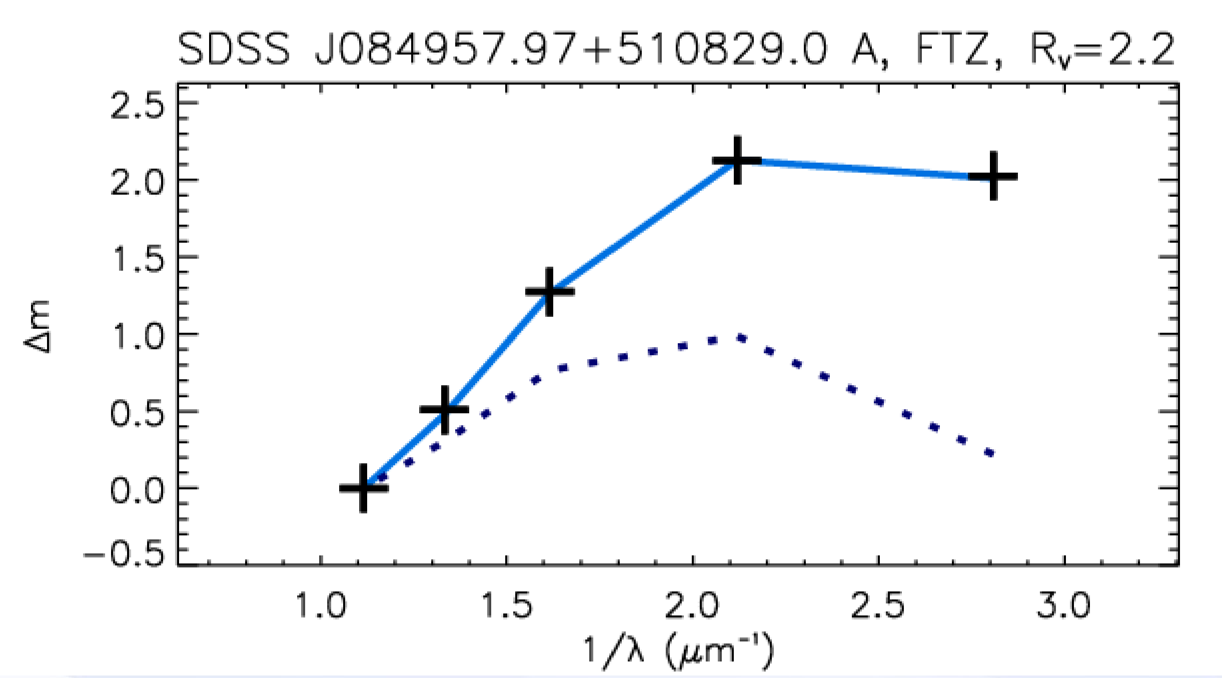
Error estimates

- Uncertainty in the observed magnitudes of the quasar
- Uncertainty in the template colours
  - From colours of SDSS quasars with z ± 0.05
  - Include intrinsic colour variations

Example system:

- SDSS J084957.97 +510829.0 (z=0.6)
- 2MASX J08495751+5108416 (z = 0.07)





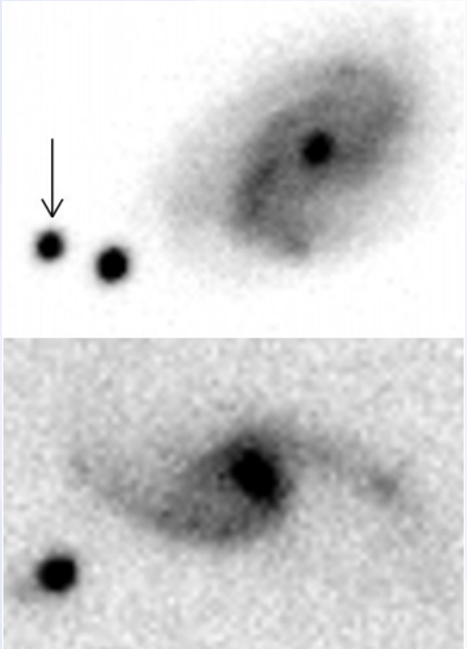
Dust extinction outside the petrosian radius of a galaxy

- Coordinate matching of SDSS Quasar catalogue DR 3 with NYU-VAGC

- (1) χ^2 for no dust worse than 90% random quasars without foreground galaxies

  (2) χ^2 for dust better than 90% random quasars with mock galaxy.

→ 2 quasars-galaxy pairs



Fitzpatrick	Separation	Petrosian radius
$R_V = 3.4(2.4-4.7)$	15 kpc	10 kpc
$R_V = 2.2(1.5-2.9)$	19 kpc	16 kpc

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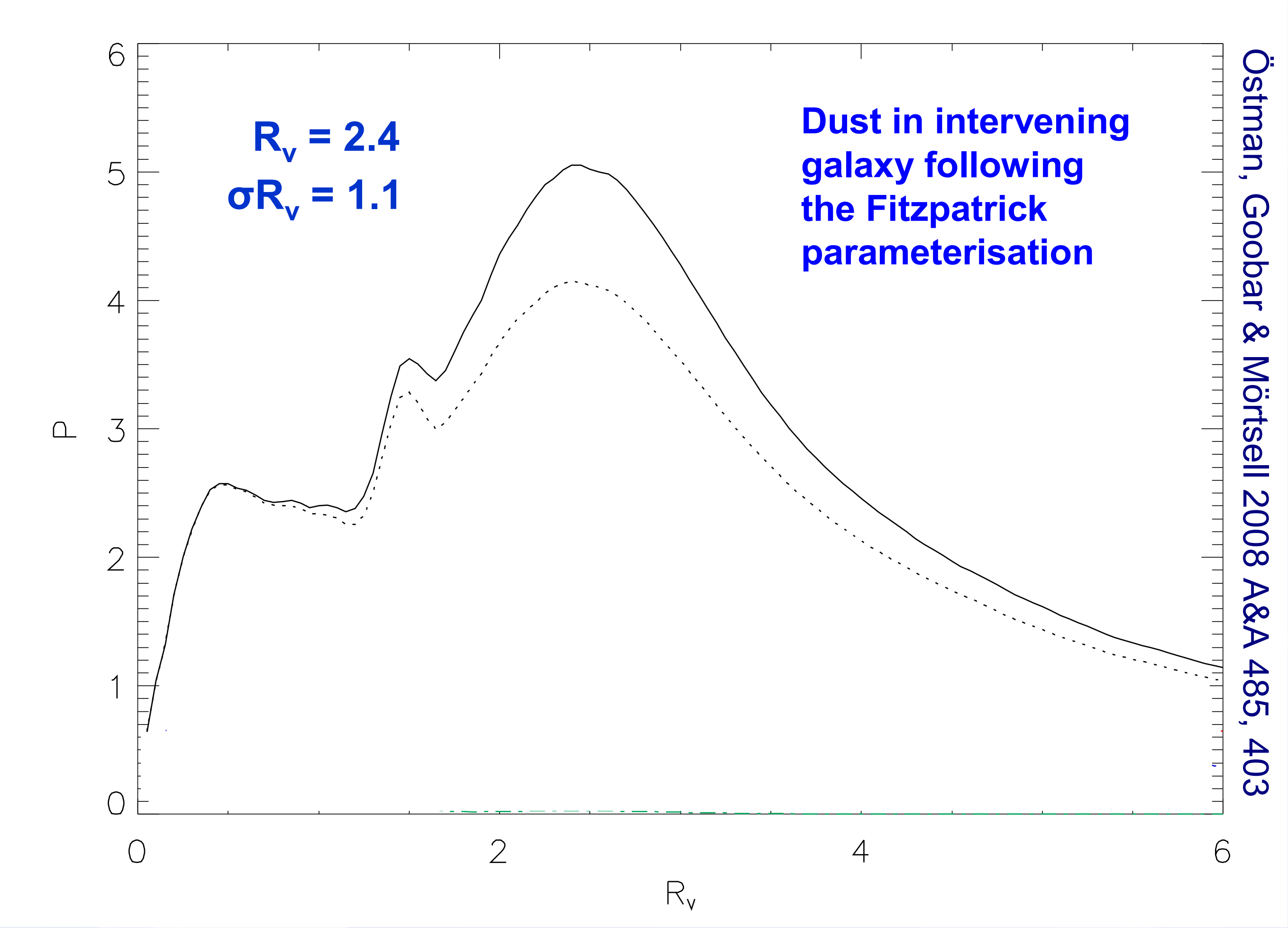
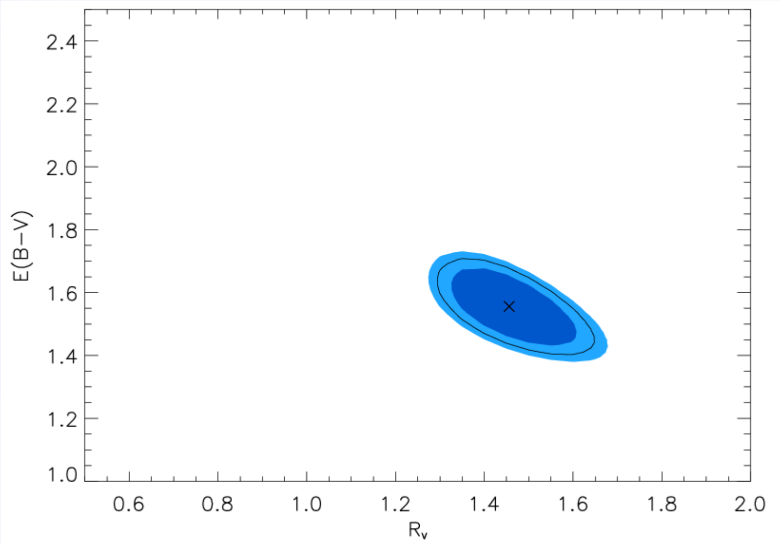
Added probability distribution for R_V



MG0414+0534 – a system with 4 images

- Quasar z = 2.64, galaxy z = 0.96
- Early type galaxy

Image	R_V
A1	$1.5(1.4-1.6)$
A2	$1.5(1.5-1.7)$
B	$1.5(1.3-1.6)$
C	$1.4(1.3-1.5)$

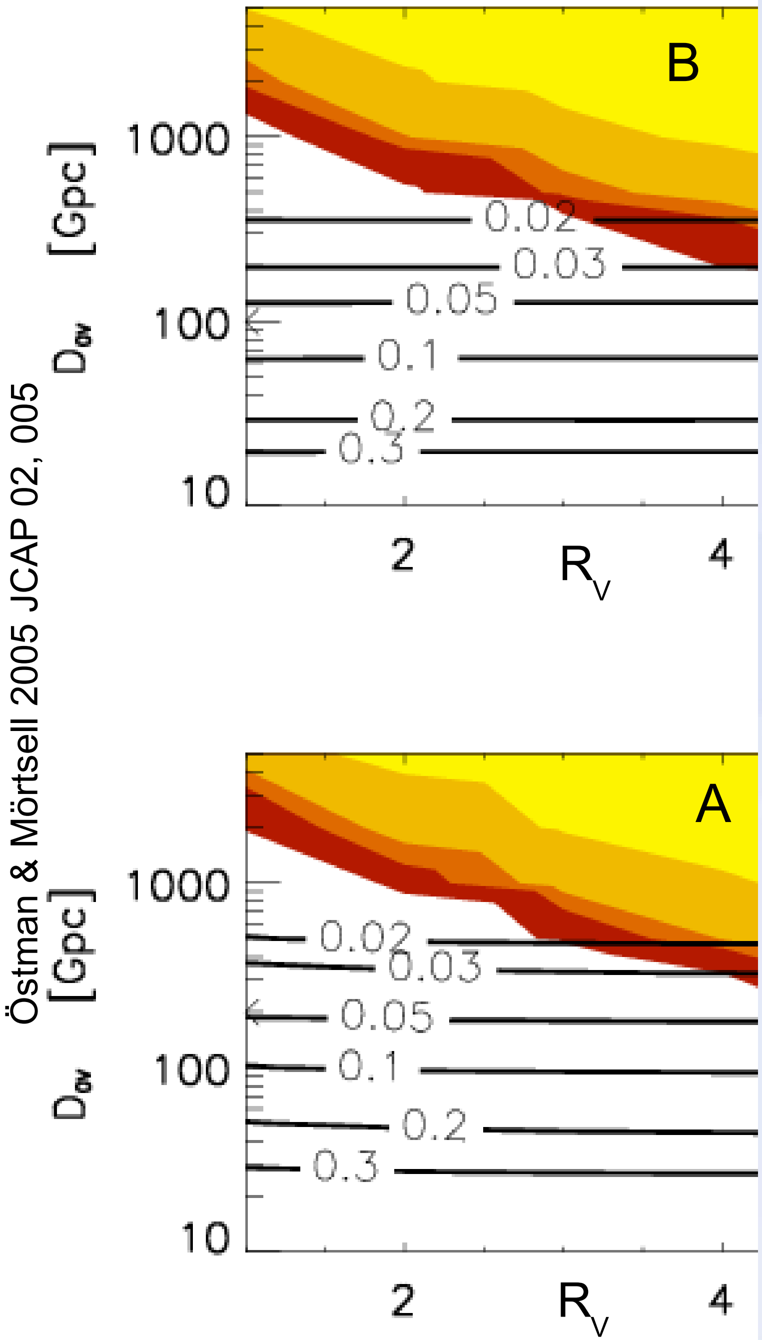


Limiting the effects from intergalactic dust using quasars

- Using SNOC (Goobar et al. 2002 A&A 392, 757), the mean colours for redshift bins of size 0.05 are simulated
- Vary R_V and the interaction length D_{0V}
- Two different models for the evolution of the dust density

$$A: \quad \rho = \rho^0 (1+z)^3$$

$$B: \quad \rho = \rho^0 (1+z)^\alpha \qquad \begin{array}{l} \alpha = 3 \ for \ z < 0.5 \\ \alpha = 0 \ for \ z > 0.5 \end{array}$$

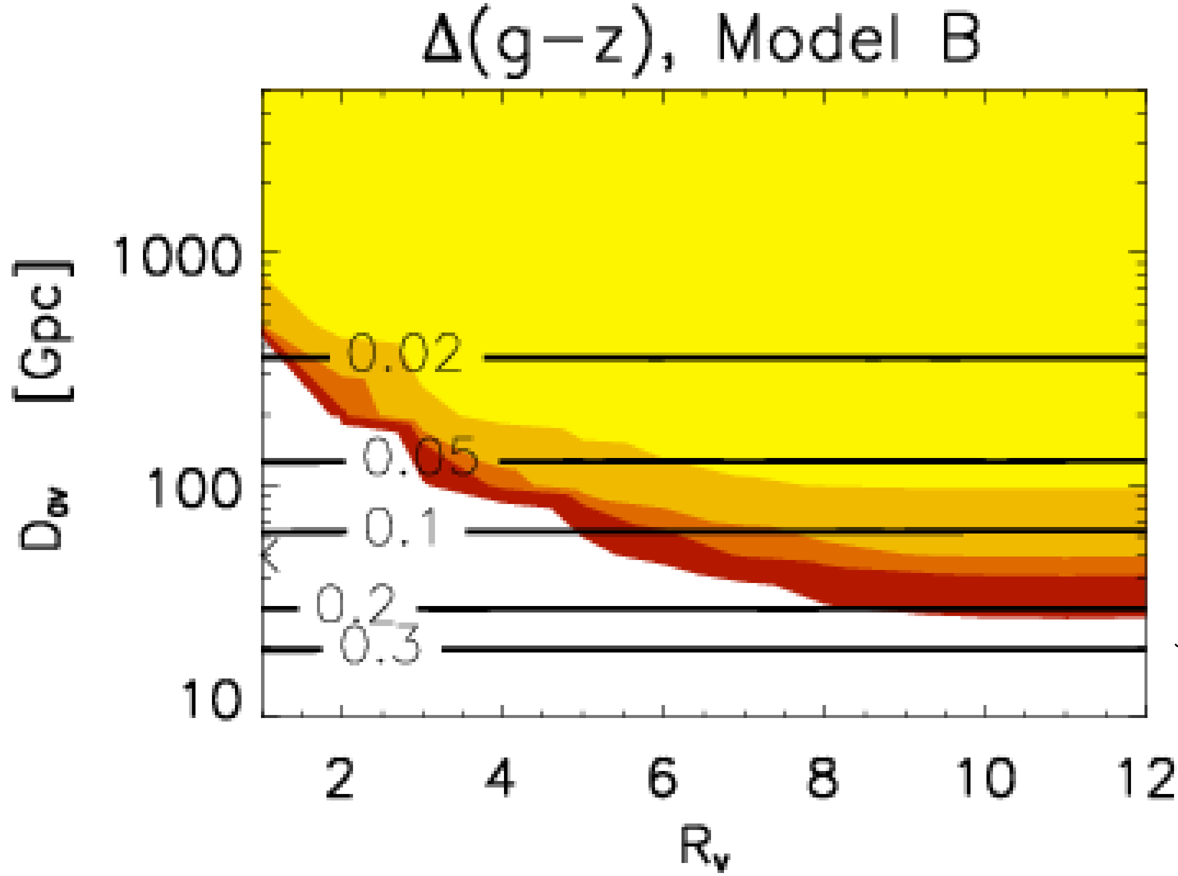


For Milky Way like dust

(R_V < 4)

Dimming < 0.03 mag in the B-band for a SN Ia at z=1

Yellow to red: 68%, 90%, 95%, 99% confidence level from χ^2 analysis
Black lines: B band attenuation in magnitudes for a SN Ia at z = 1



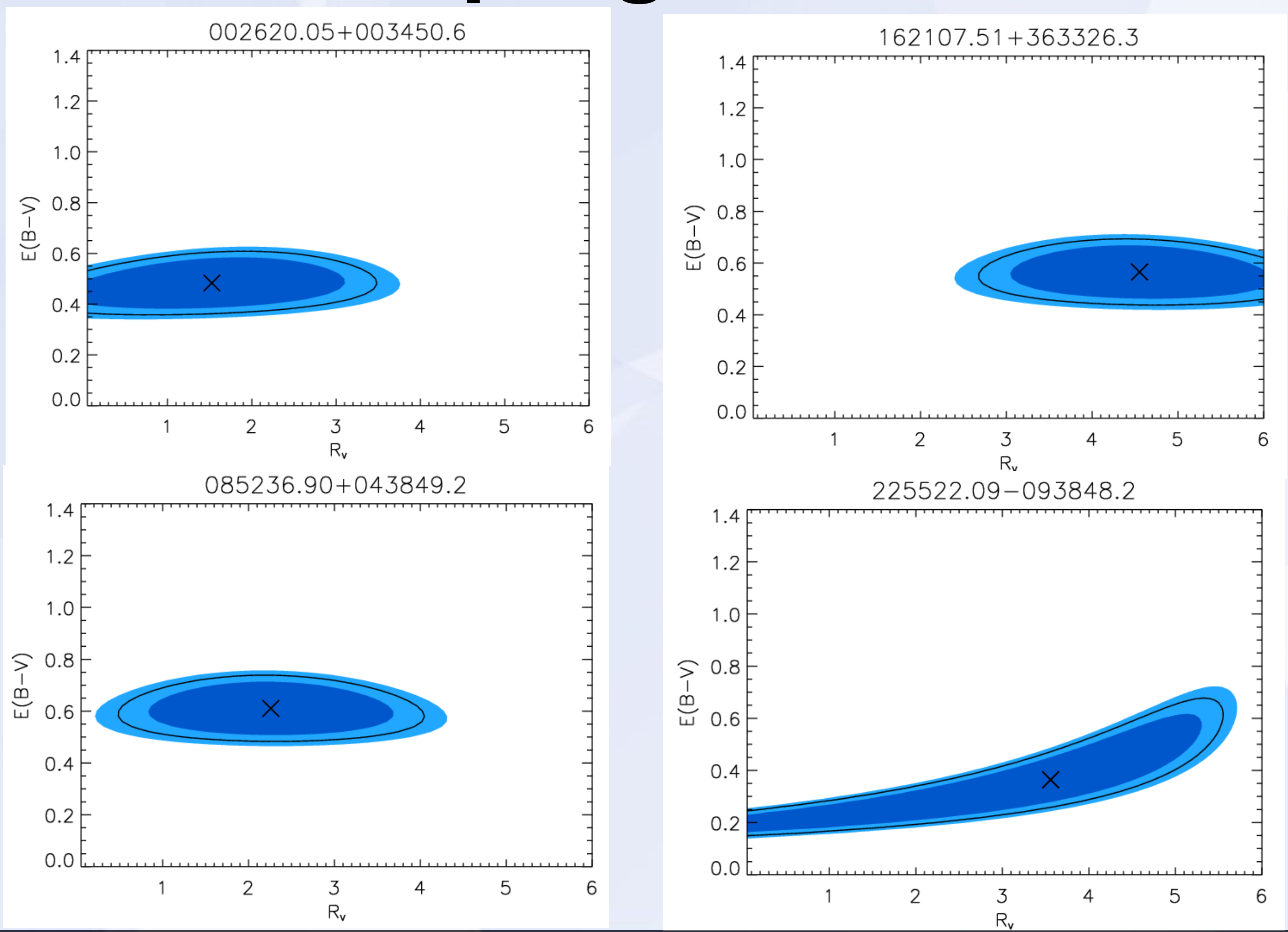
Östman & Mörtsell 2005 JCAP 02, 005

Yellow to red: 68%, 90%, 95%, 99% confidence level
Black lines: B band attenuation in magnitudes for a SN Ia at z = 1

Allowing for grey dust (R_V > 4)

Dimming < 0.2 mag in the B-band for a SN Ia at z=1

In progress...



002620.05+003450.6
162107.51+363326.3
085236.90+043849.2
225522.09−093848.2
E(B−V)
R_v
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1
2
3
4
5
6