# Constraining Dark Energy with Supernovae la The Role of Gravitational Lensing

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CAM 2007

**McGill University** 



### The Think Tank

- Prof. Asantha Cooray, UC Irvine
- Dr. Daniel Holz, Los Alamos National Lab
- Dr. Alexandre Amblard, UC Irvine

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# The Help Desk

- CAM 2007 Organizers
- Kyler Kuehn, UC Irvine
- Daniel A. Beaton, UBC



### Why Spend Time on Dark Energy?

Why Spend Time on Dark Energy?
 SNe la: Trying to Steal the Show!

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 Role Played by Gravitational Lensing

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Today: What are we up to?

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### Why Dark Energy?





 $\left(\Omega_X \equiv \frac{\rho_X}{\rho_{crit}}\right)$ 

$$w = 0$$
 for mat  
 $p = w\rho$   $w = \frac{1}{3}$  for rad  
 $w = -1$  for  $\Lambda$ 



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#### Are we sure that

$$w = -1$$

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 $w = -1$  for  $\Lambda$ 











What if the EOS varies with time?







What if the EOS varies with time?

### How are SNe sensitive to Cosmology?

Known Intrinsic Brightness Observed flux depends on the distance of the SNa from us

Oistance depends on the cosmological parameters



#### The Box Office in 1998

### But why Gravitational Lensing?



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Lensing Galaxy



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Lensing Galaxy



#### Thus Lensing can Modify Supernova Flux

$$\mathcal{F}^{\text{obs,lensed}}(z, \hat{\mathbf{n}}) = \mu(z, \hat{\mathbf{n}}) \mathcal{F}^{\text{obs,true}}(z)$$



Wang, Y., Holz, D. E., & Munshi, D., 2002, ApJ, 572, L15

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