Colorful Investigations of WFIRST

Ryan Foley
University of Illinois

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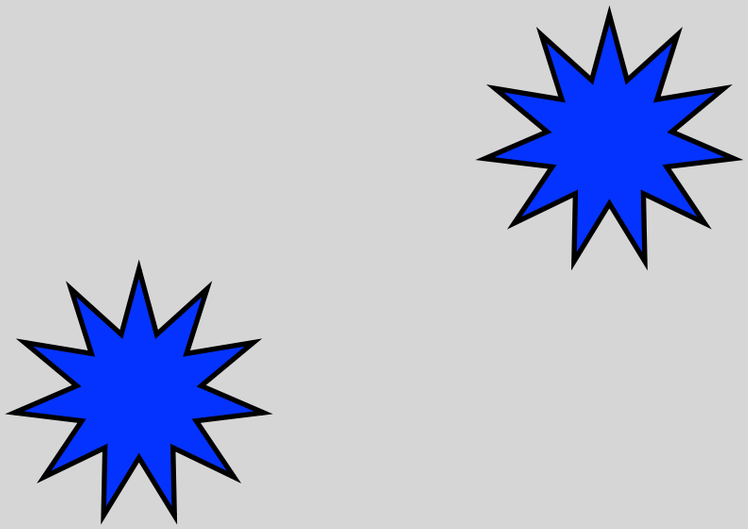
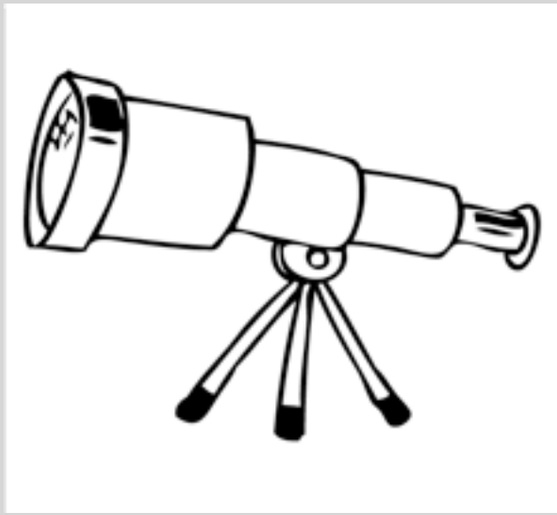
Scolnic, Hounsell, Kessler

Standard Candles And Distances





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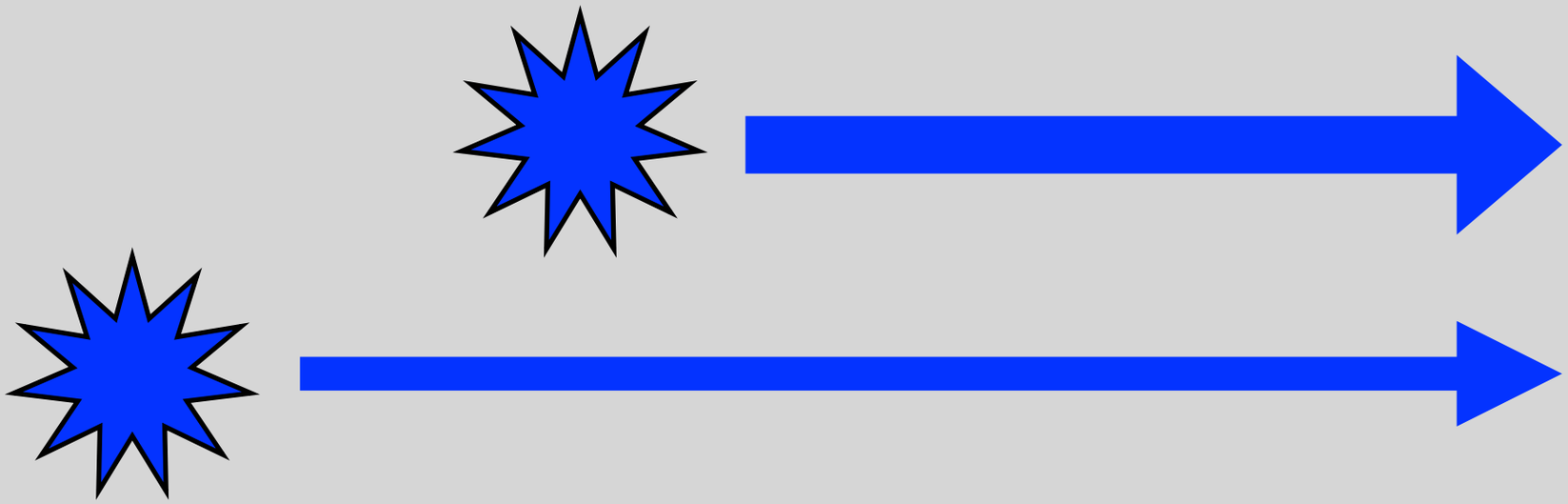

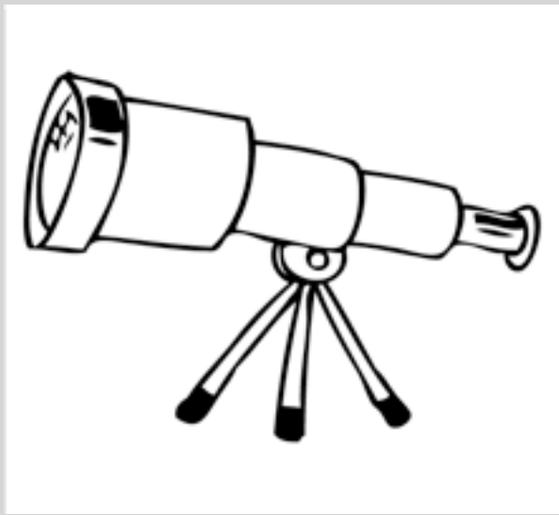

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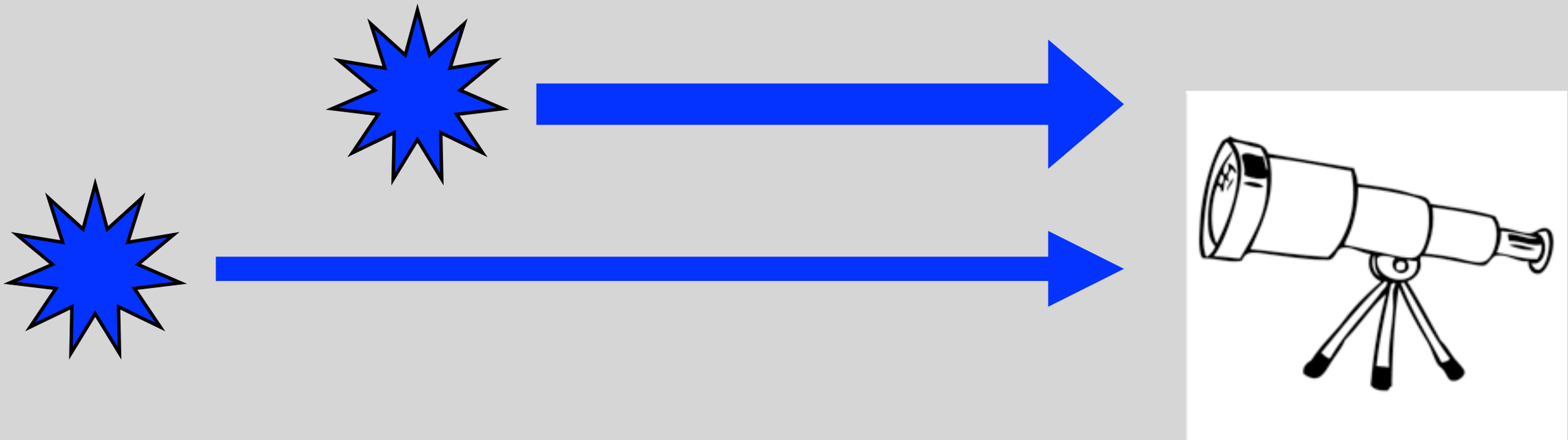
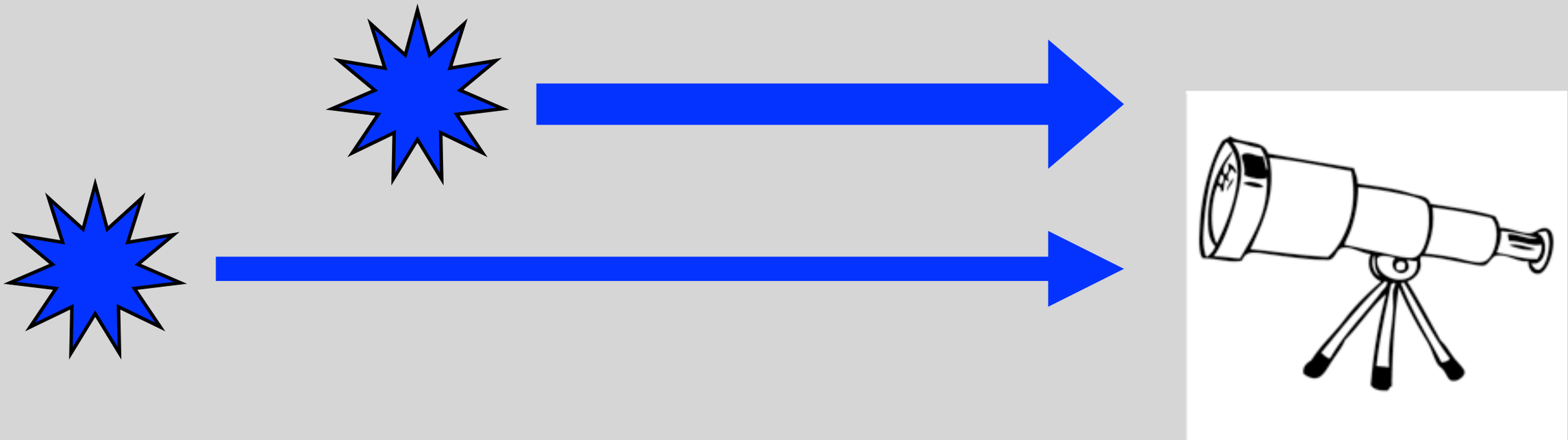


Obs: $D = (L/4\pi F)^{1/2}$

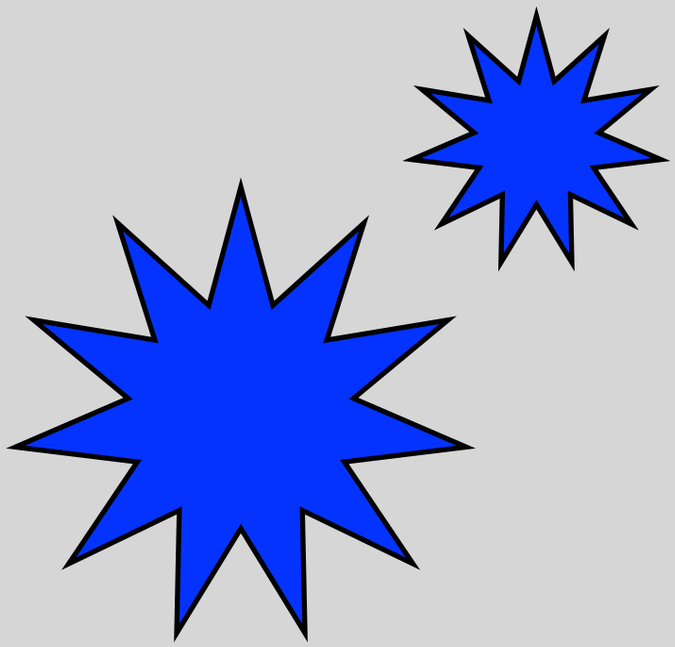
Standard Candles And Distances

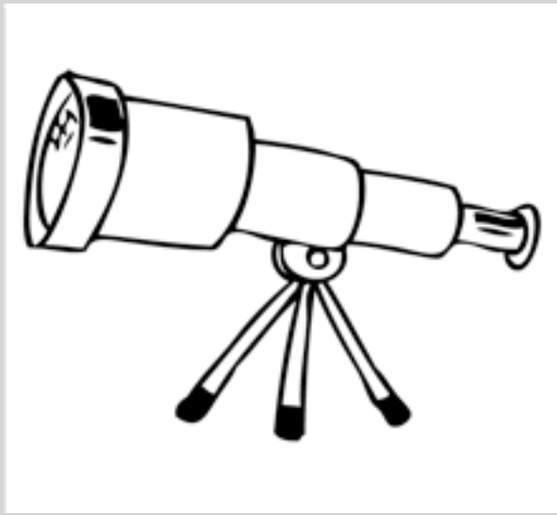


Obs: $D = (L/4\pi F)^{1/2}$

Theory: $D = f(z, \Omega, w(z), \text{etc})$

SNe Ia are NOT Standard Candles!





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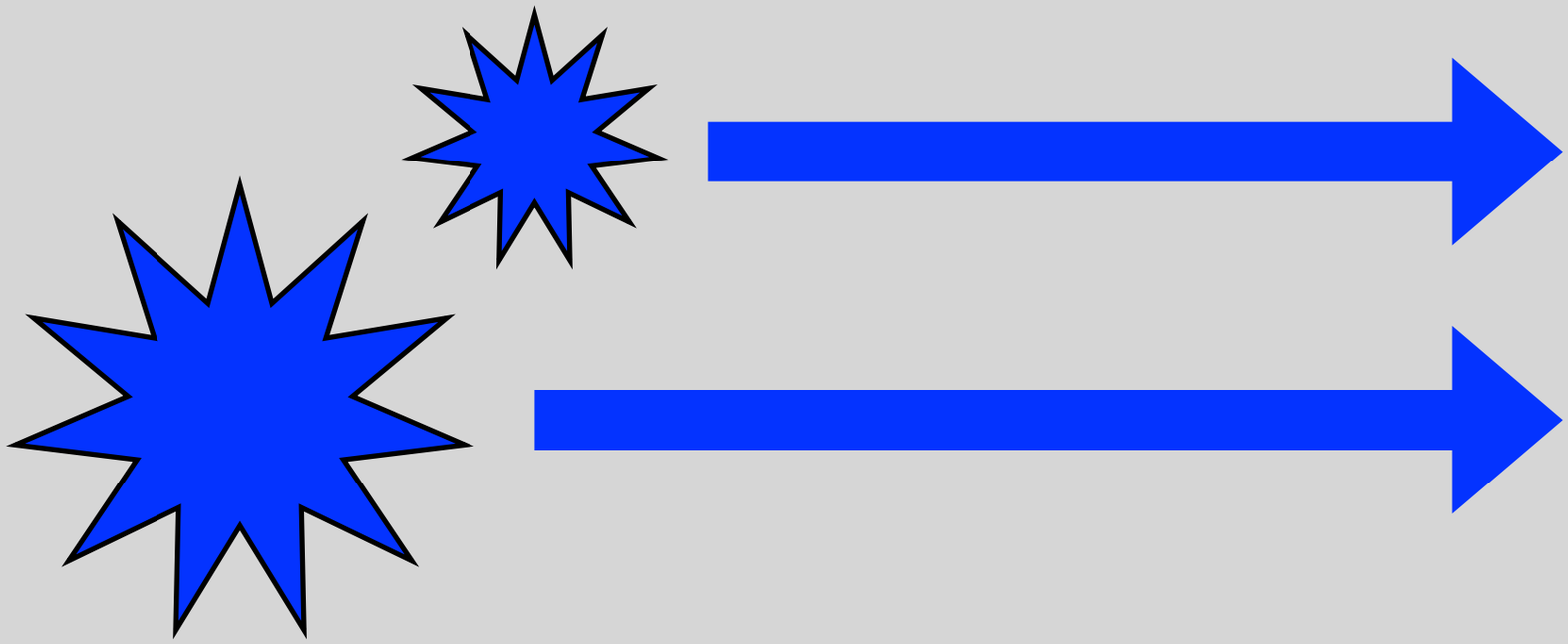
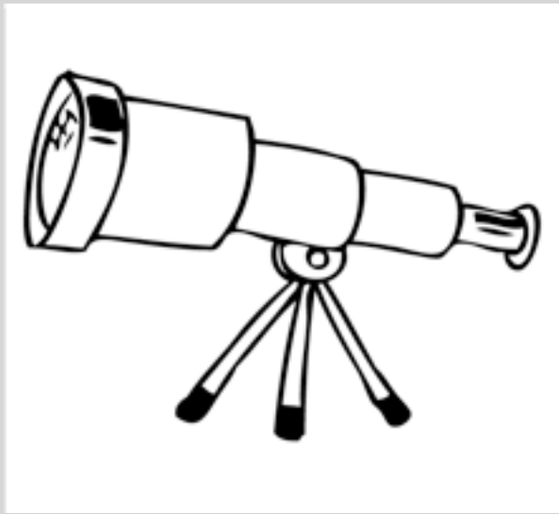
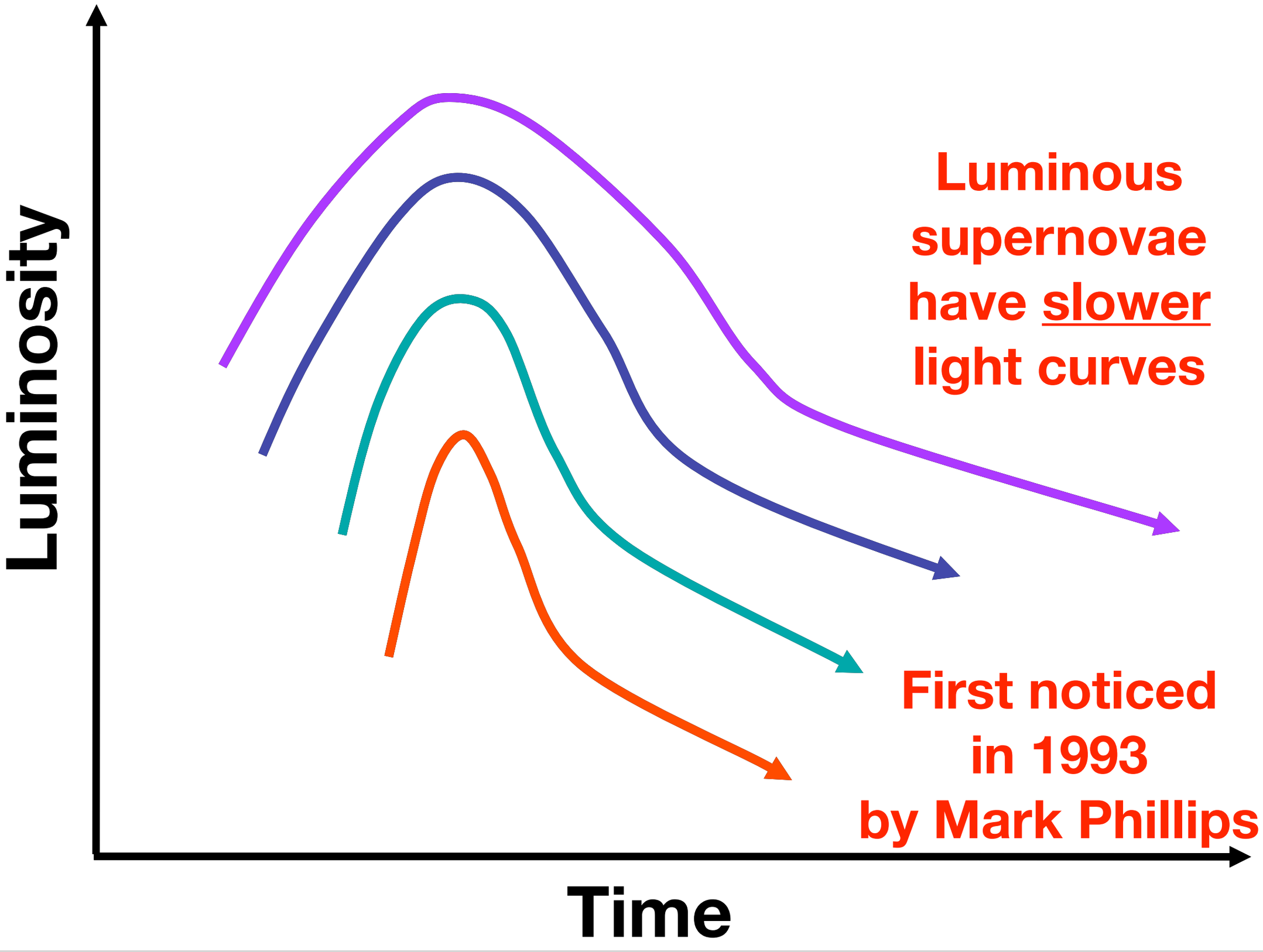




Calibrating the Nearly Standard Candle



Systematics Dominate SN Cosmology

Source	dw
Total Uncertainty	**0.072**
Statistical Uncertainty	0.050
Systematic Uncertainty	**0.052**
Photometric calibration	**0.045**
SN color model	0.023
Host galaxy dependence	0.015
MW extinction	0.013
Selection Bias	0.012
Coherent Flows	0.007

Scolnic et al. 2014

Dust Makes Things Fainter/Redder

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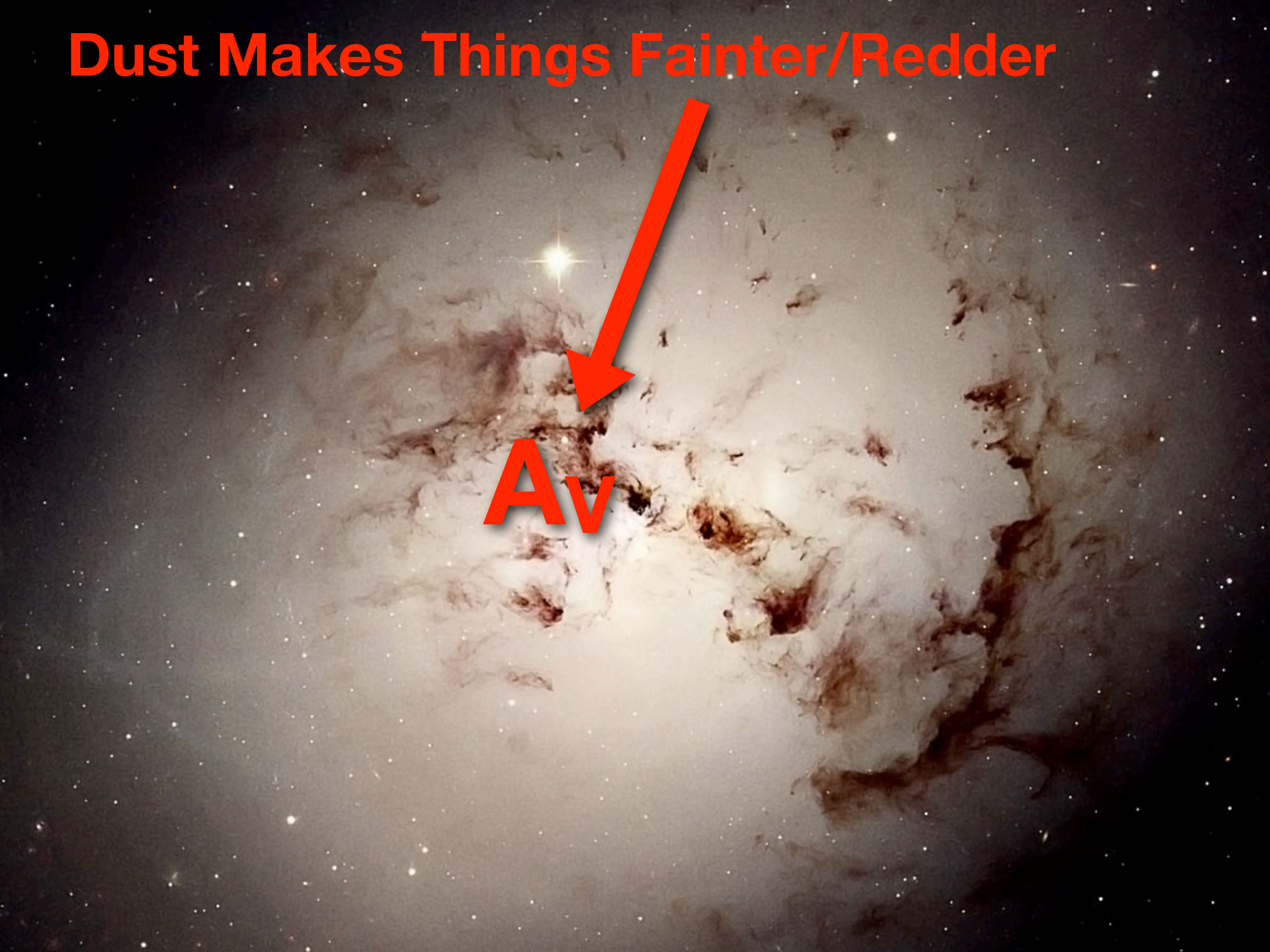

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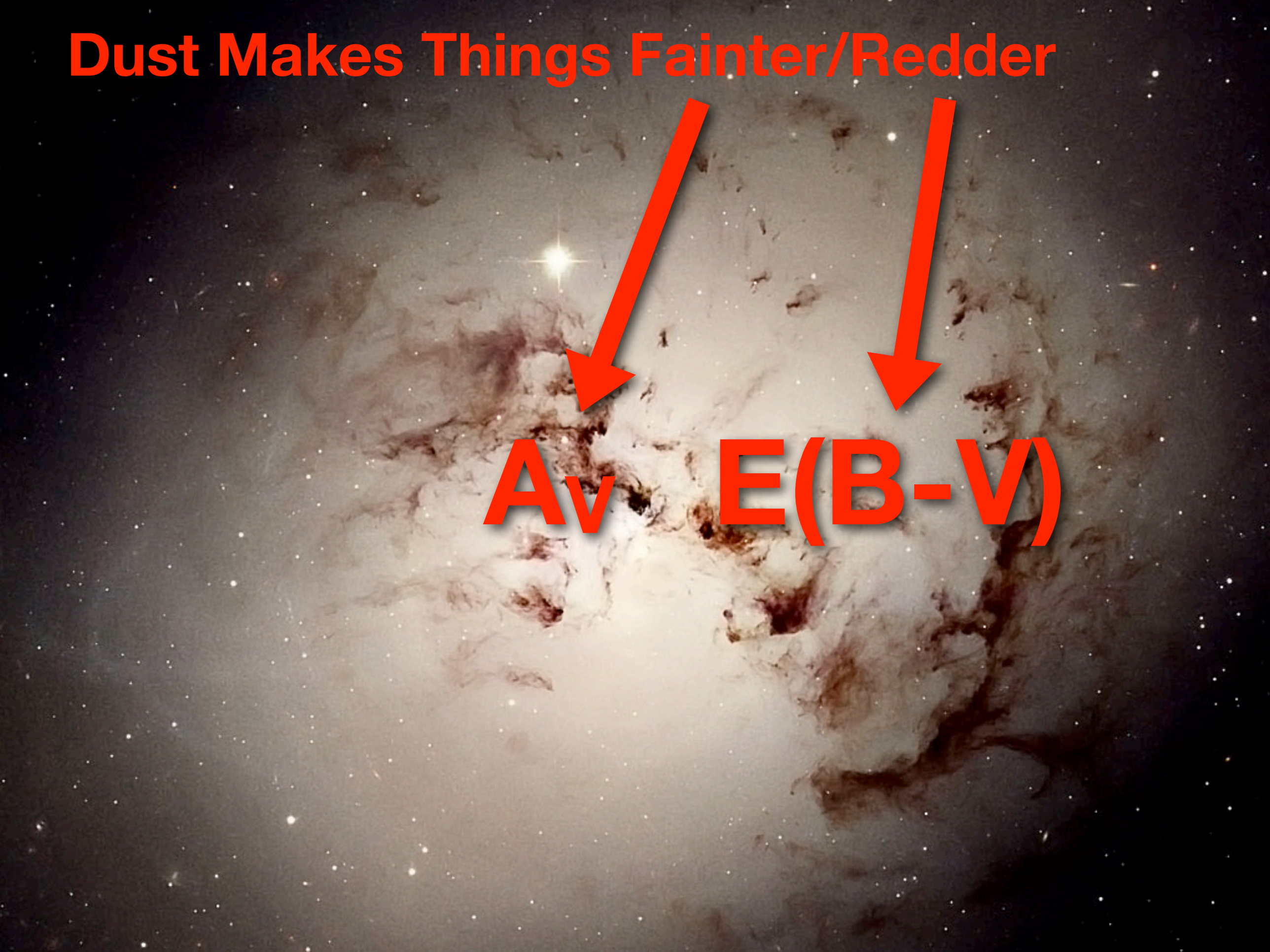

Av E(B-V)

Dust Makes Things Fainter/Redder

$$R_V = A_V / E(B-V)$$

Dust Makes Things Fainter/Redder

$$R_V = A_V / E(B-V)$$

$$\mu = m - M - A_V$$

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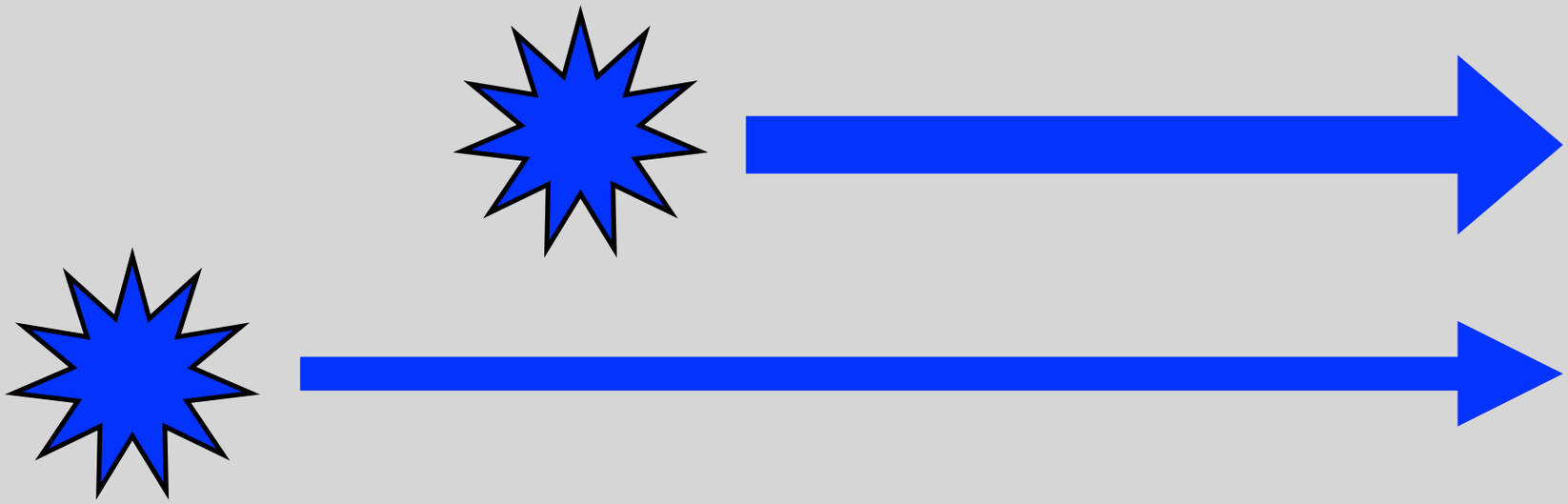

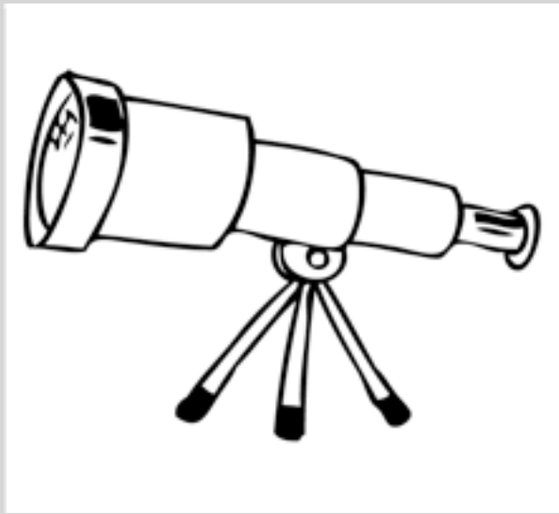

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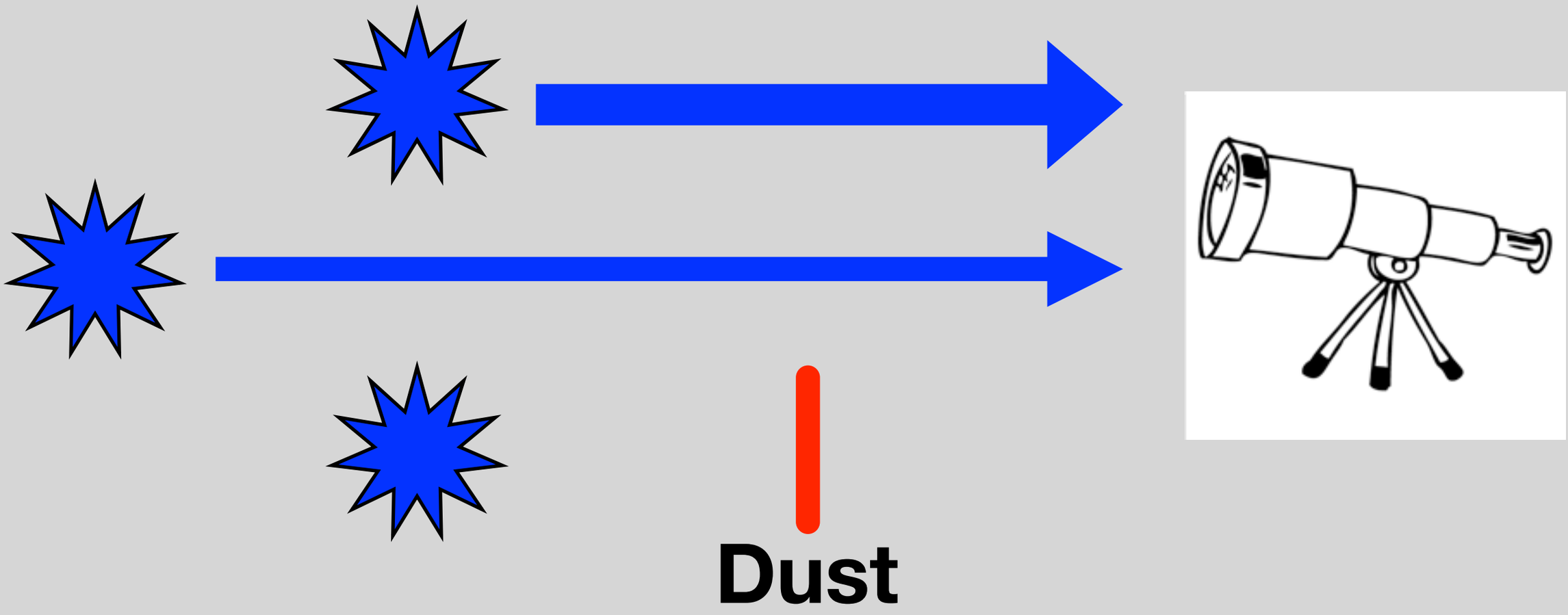

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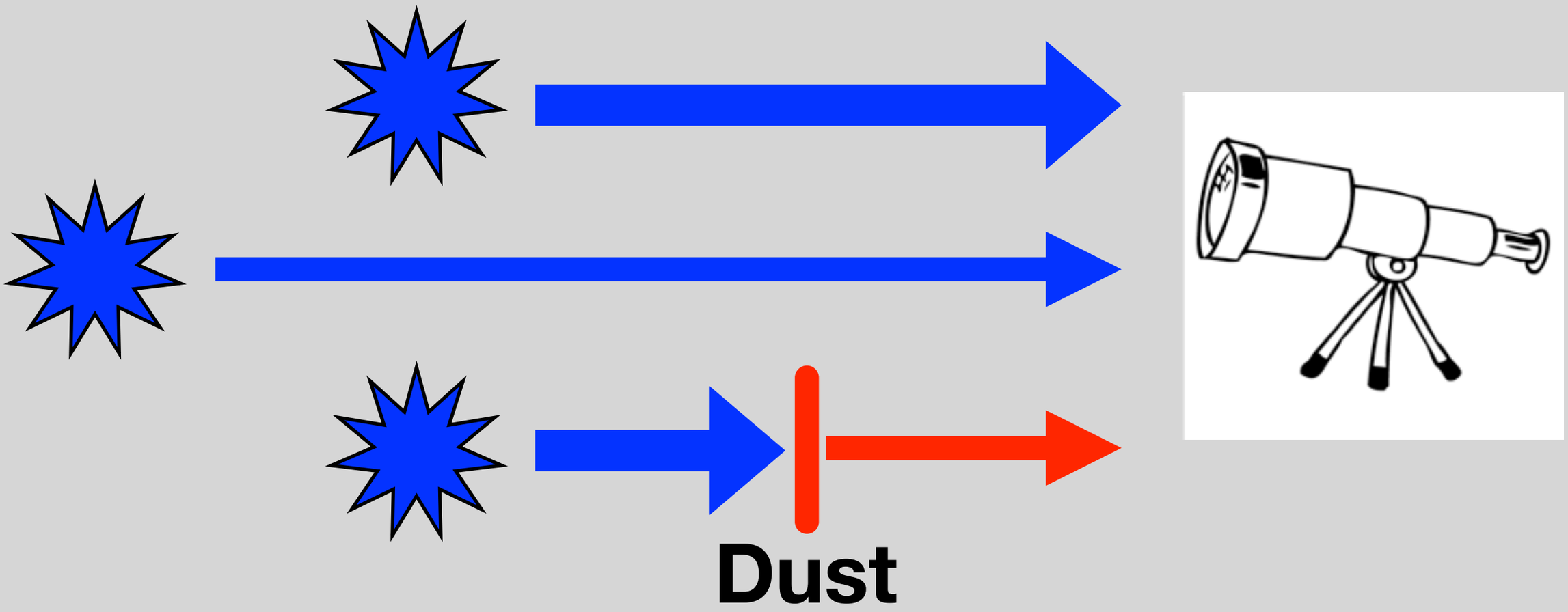


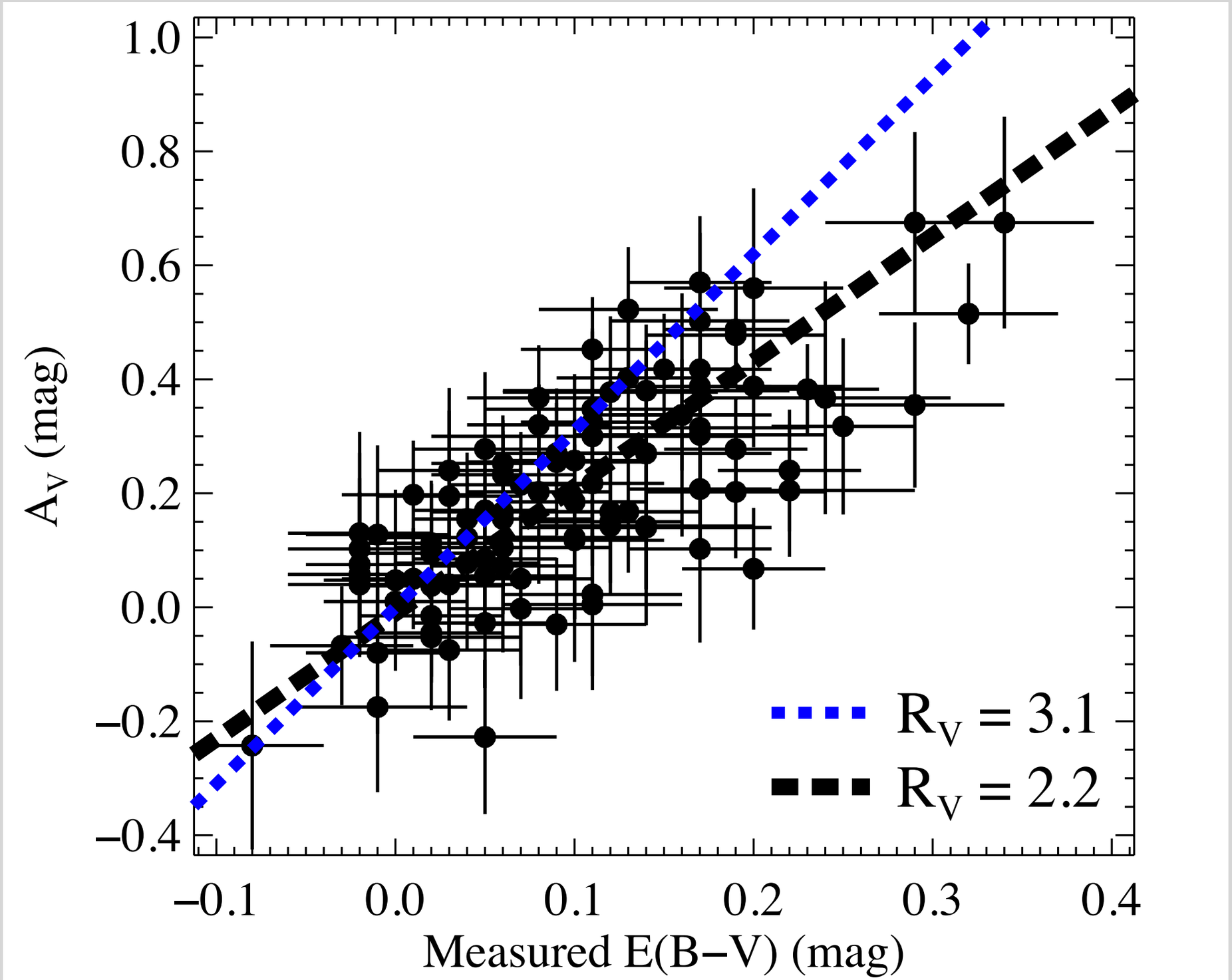
Dust Makes Things Fainter/Redder

$$R_V = A_V / E(B-V)$$

$$\mu = m - M - A_V$$

$$= m - M - E(B-V)\, R_V$$

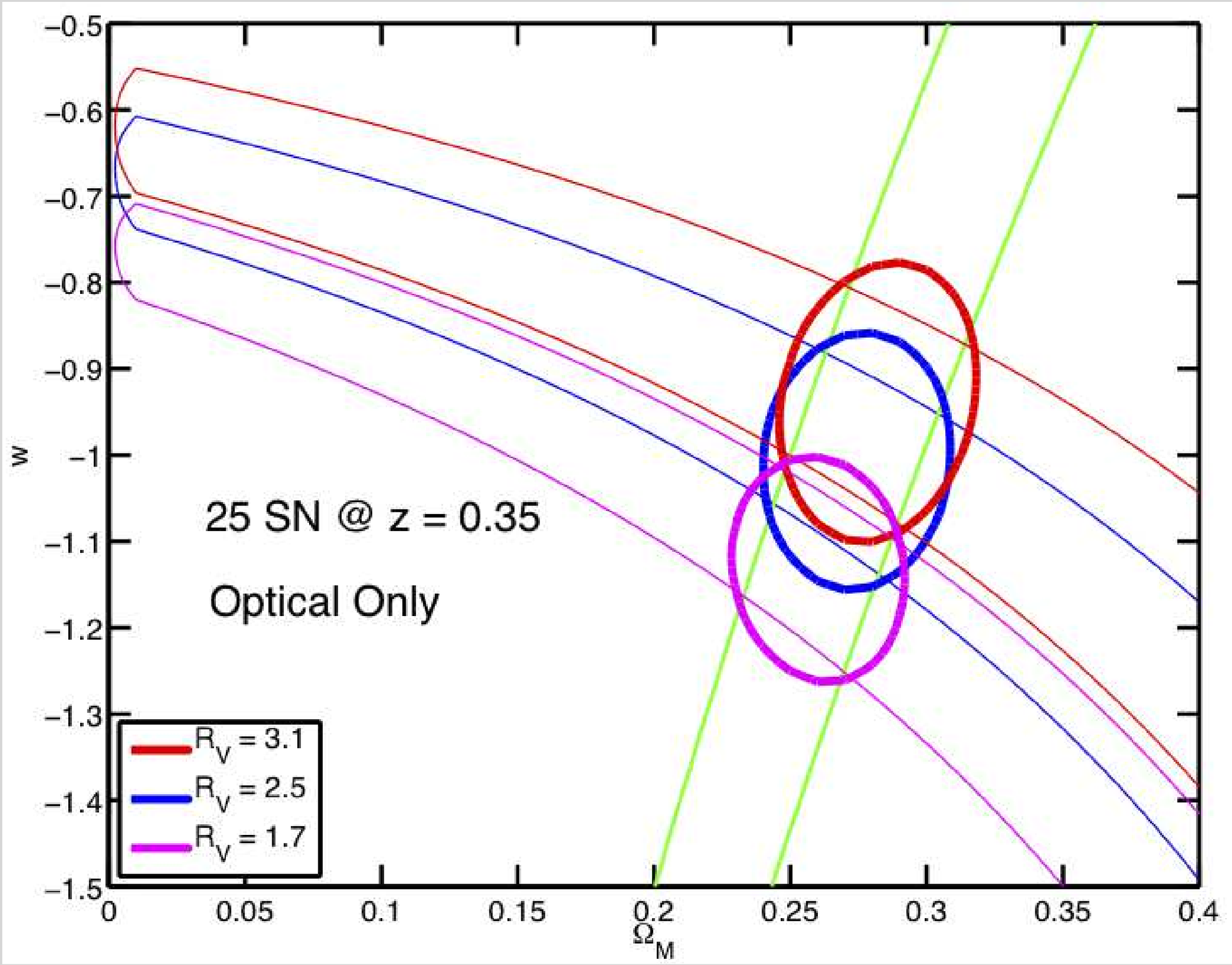
Samples of SNe Ia have Low R_V



R_V = A_V/E(B-V)

Foley & Kasen 2011

R_V Is A Significant Systematic



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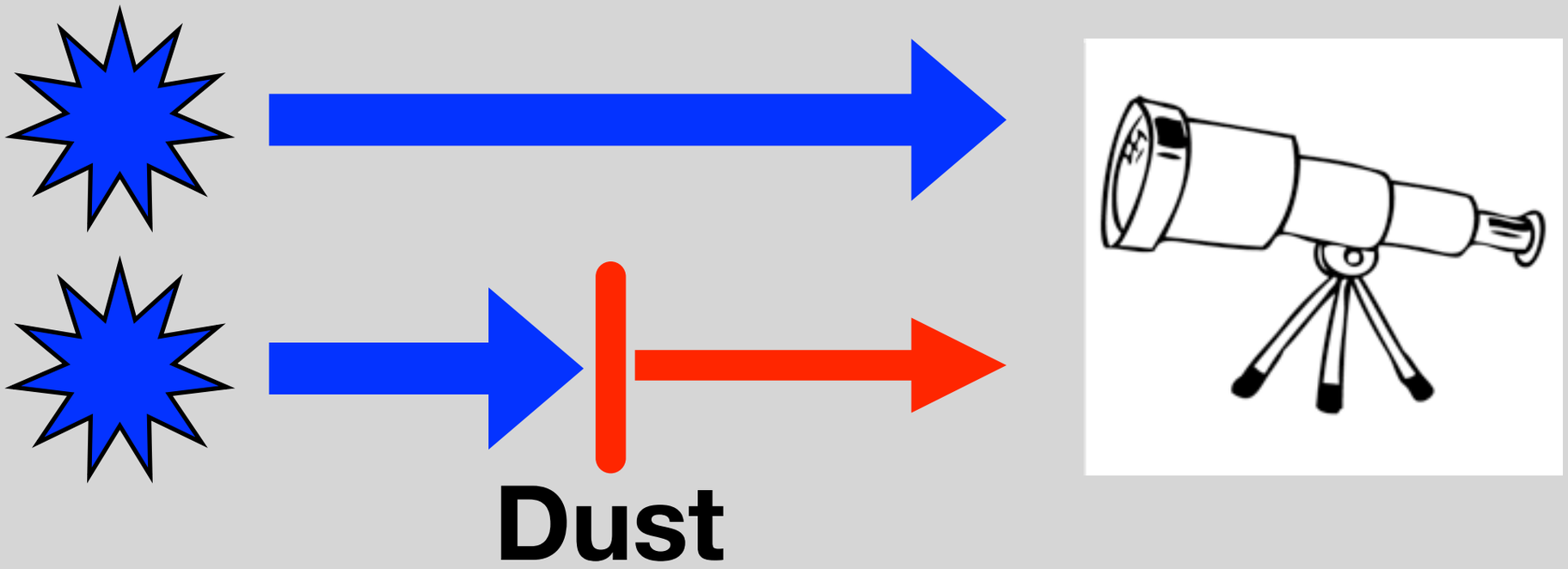

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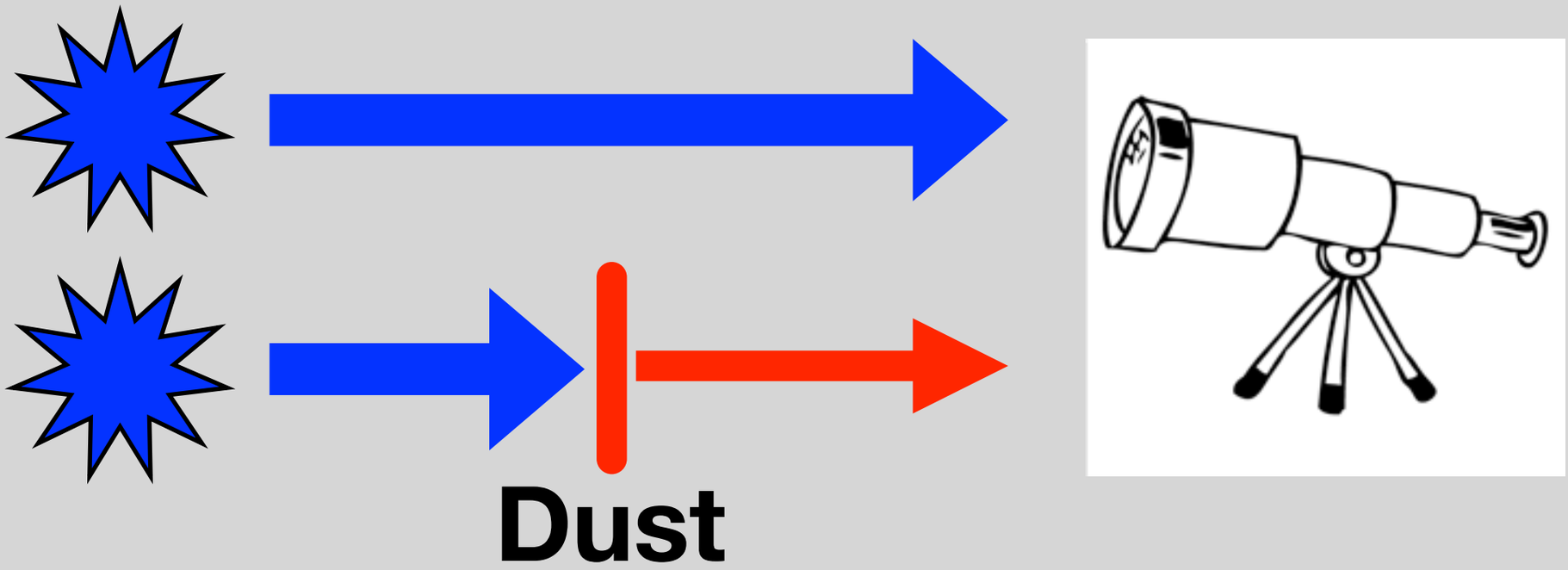
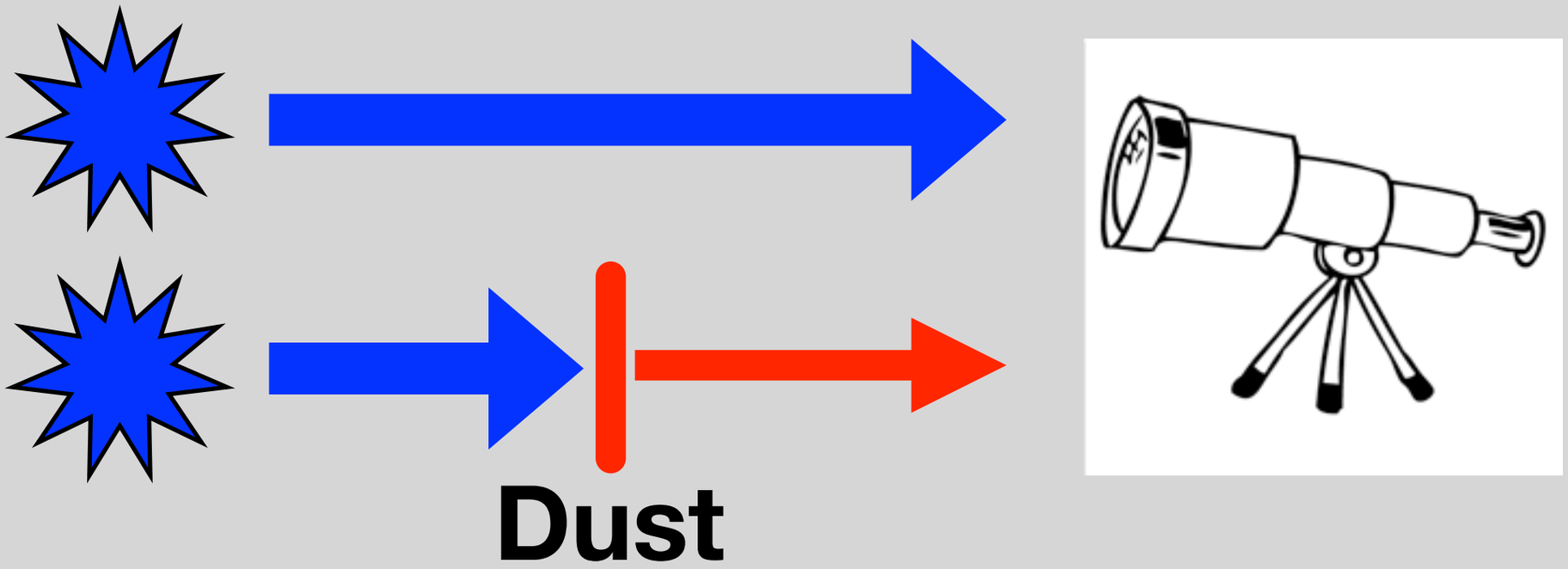


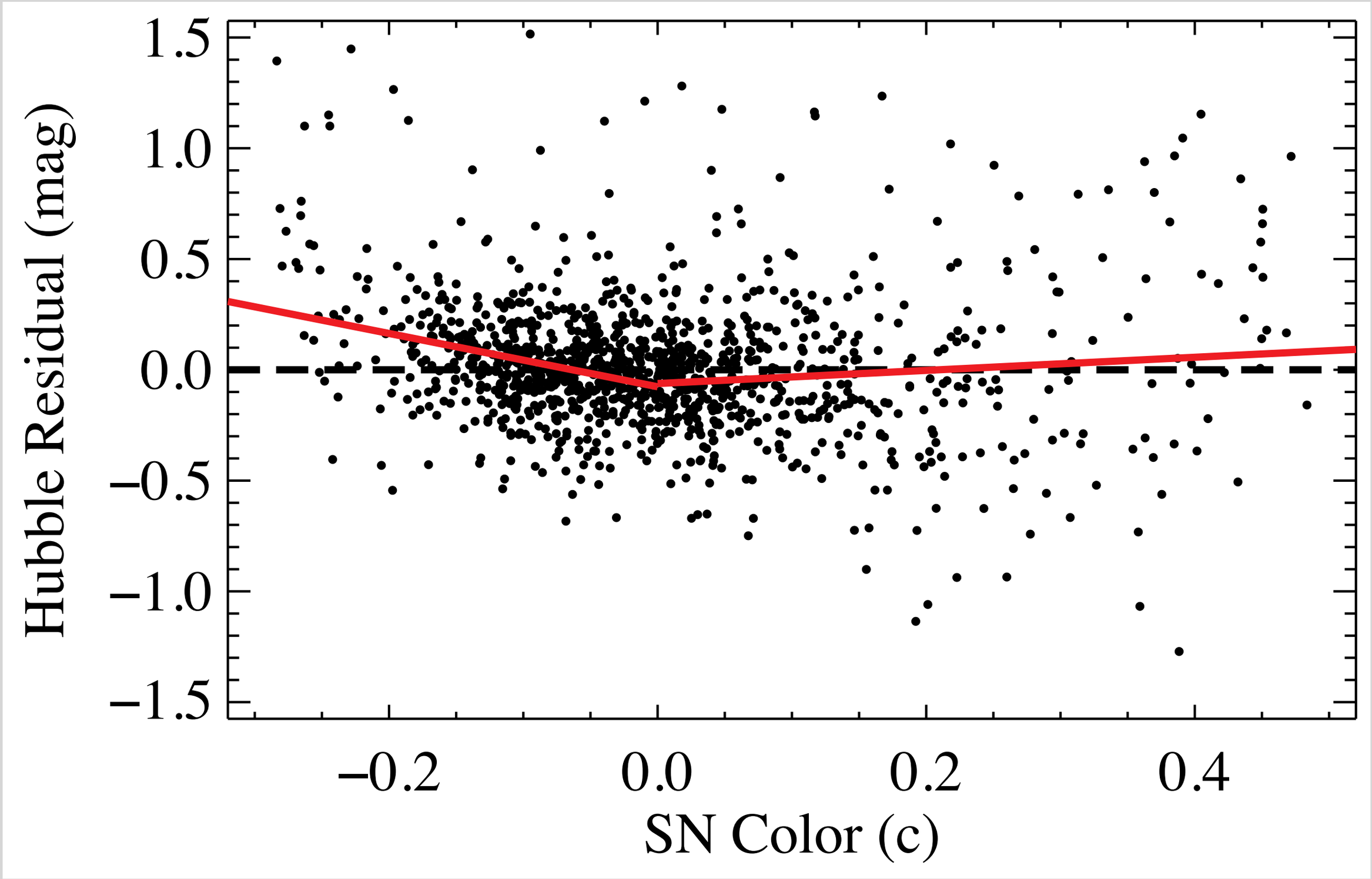
Different Intrinsic Colors

Dust Makes Things Fainter/Redder

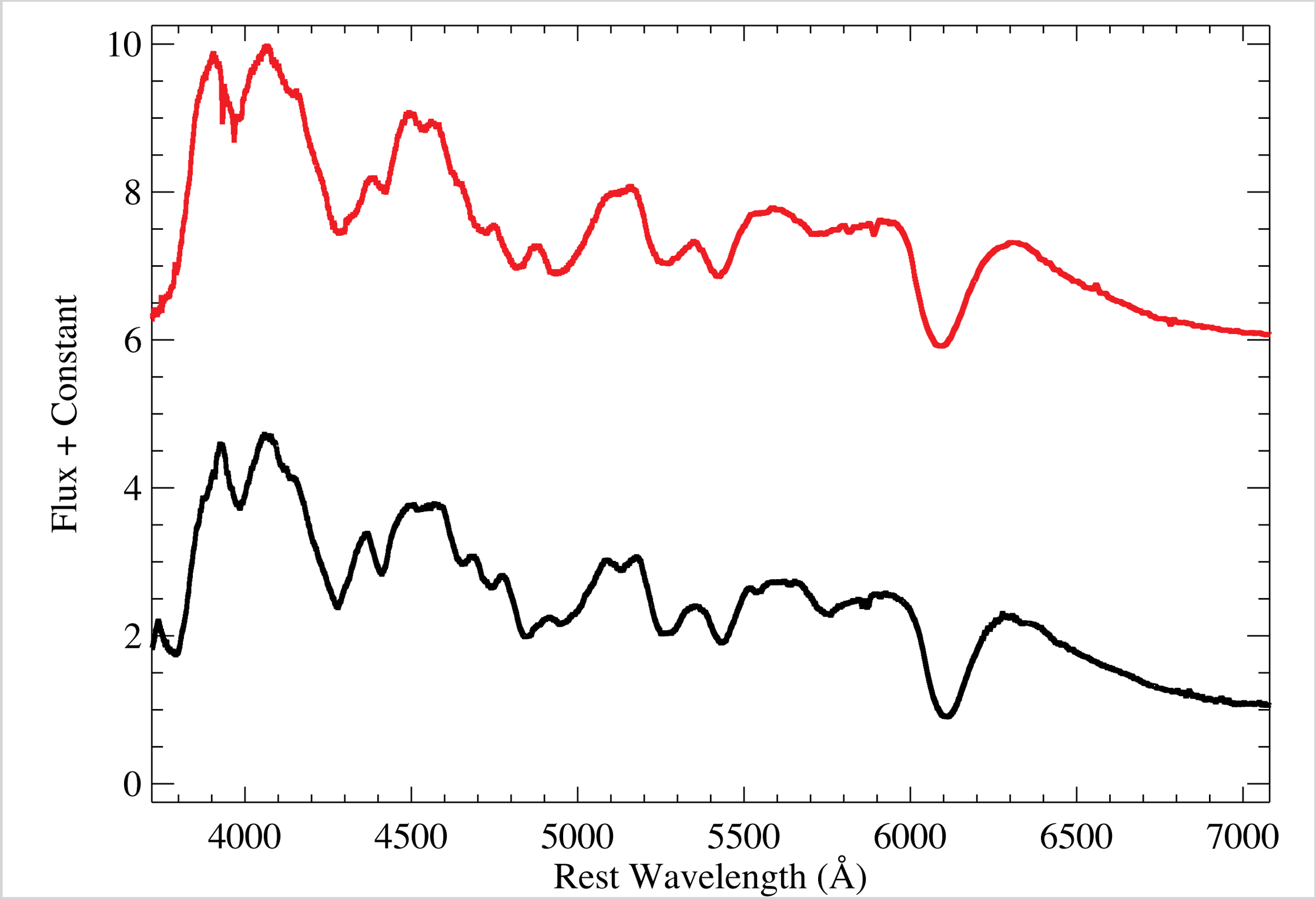


Different Intrinsic Colors

Evidence for Two Color Components



Optical Spectrum to Measure Velocity



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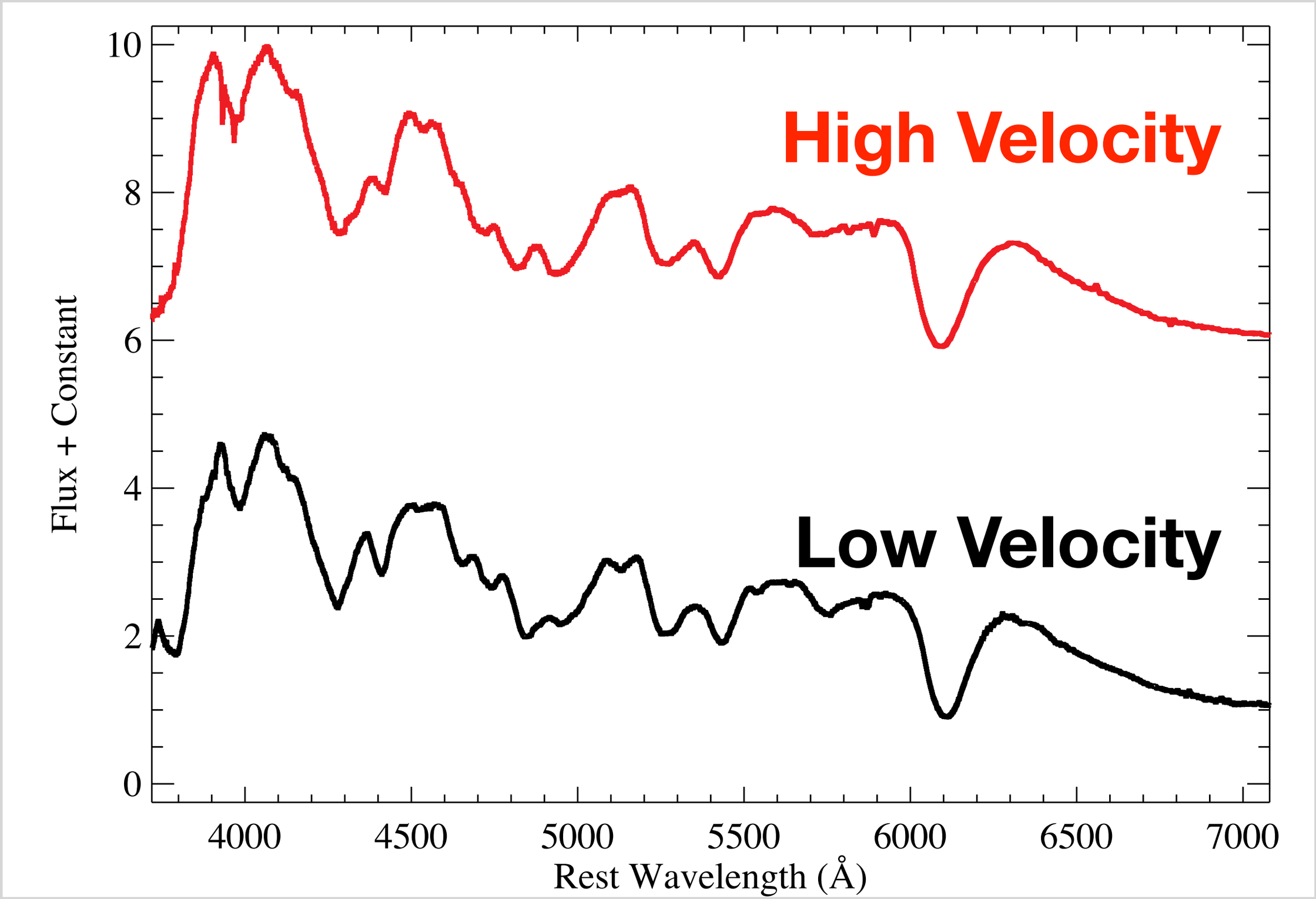
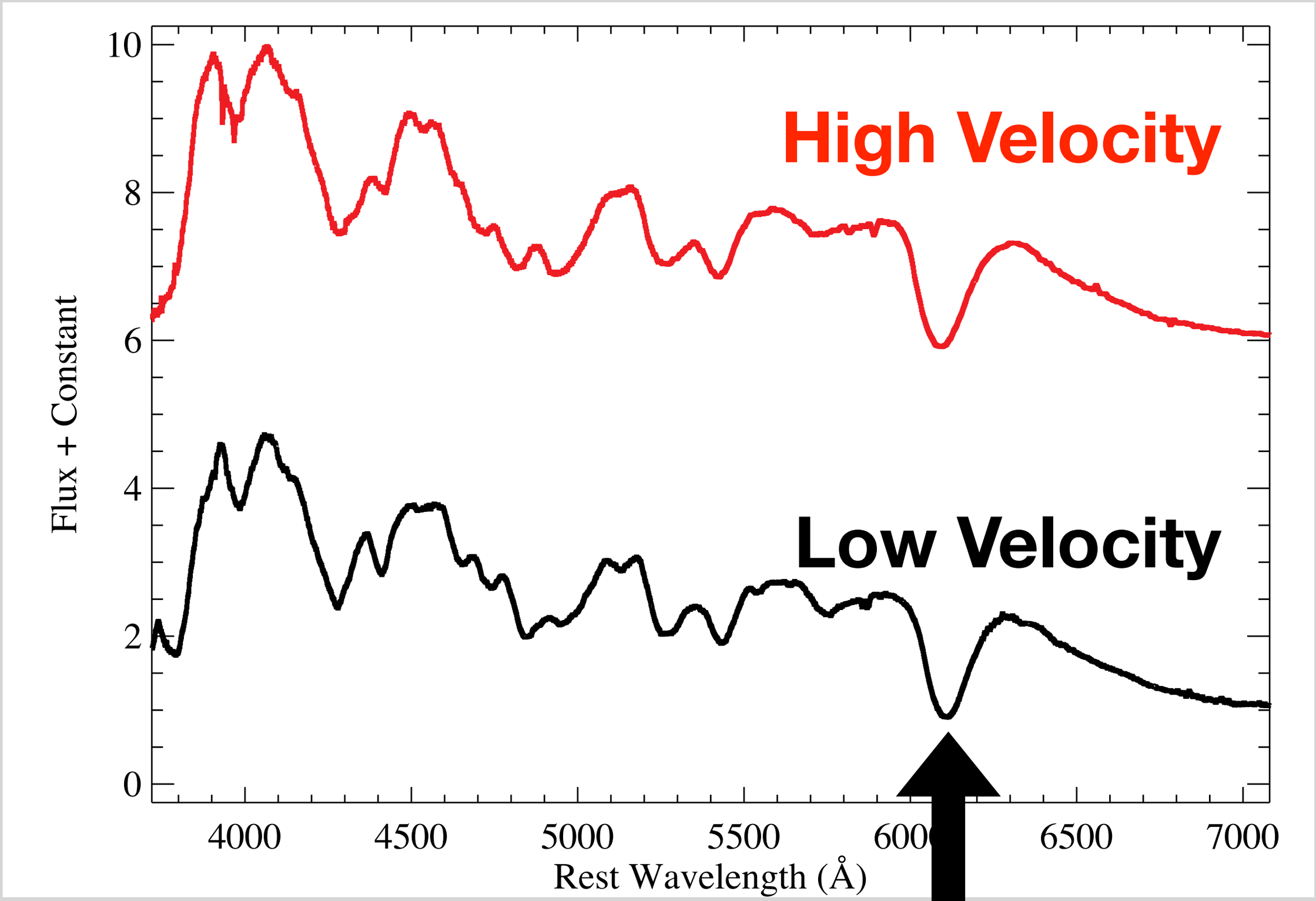
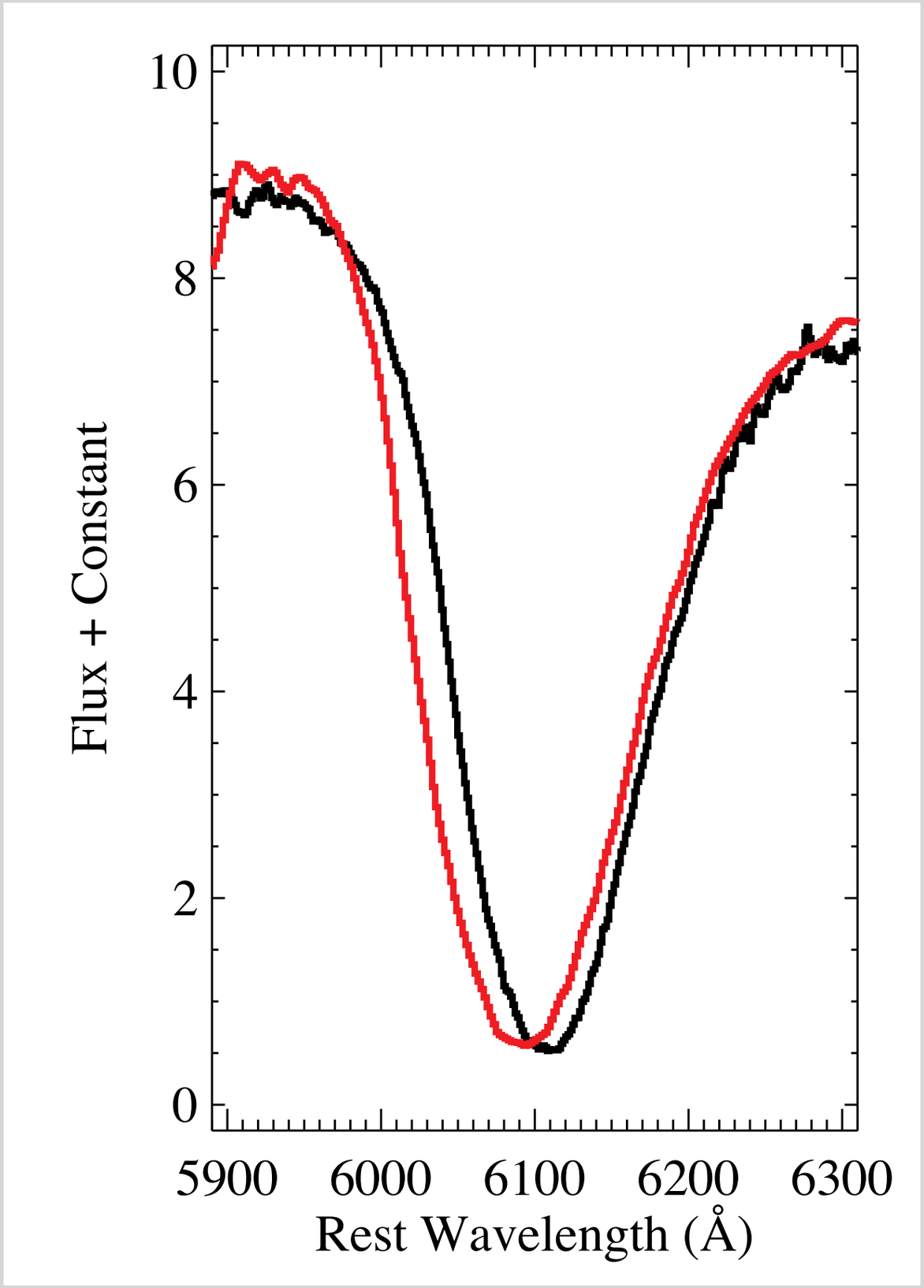


Optical Spectrum to Measure Velocity



Measure Silicon Velocity

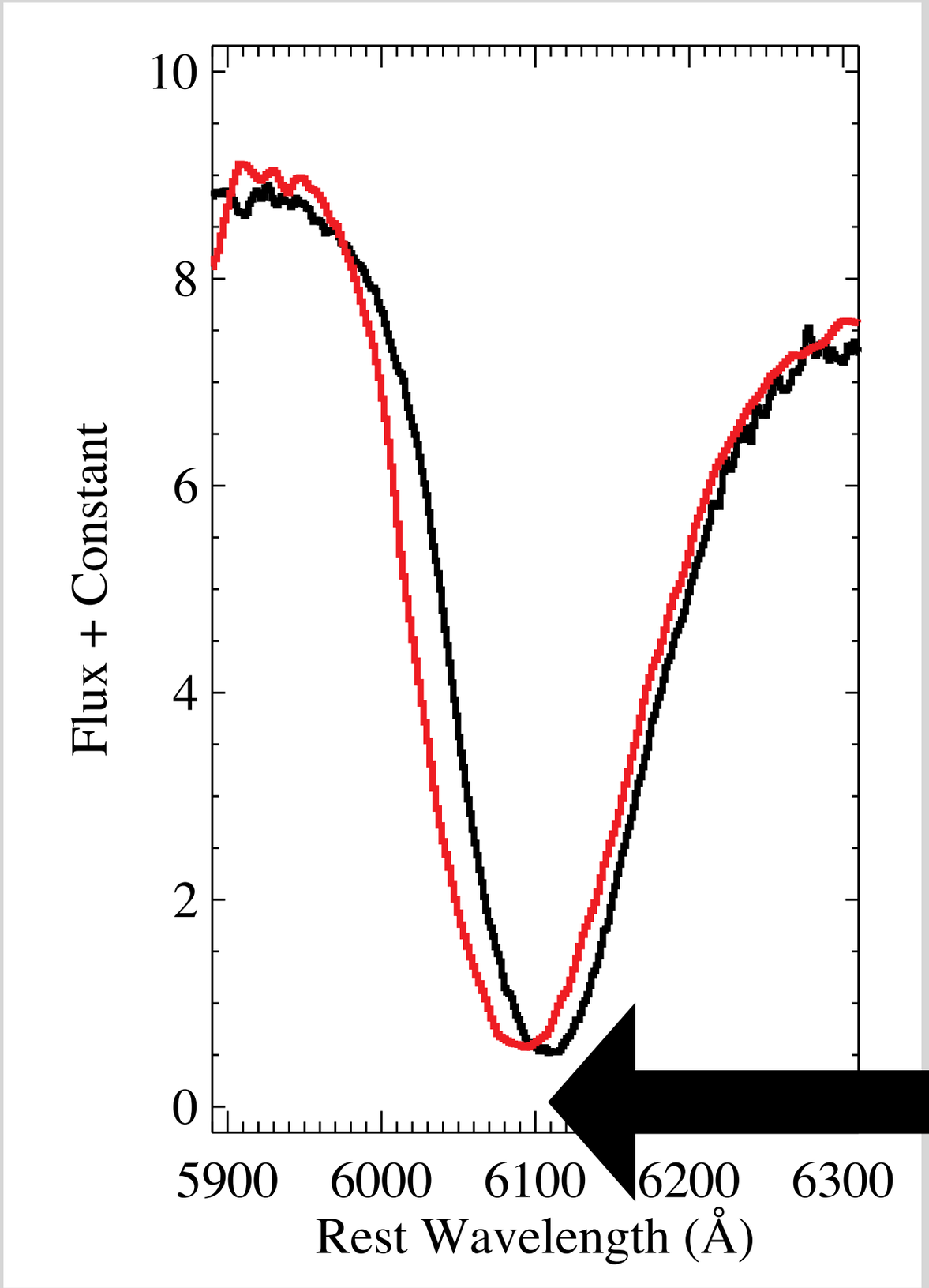


High Velocity:
~ -13,000 km s^{-1}

Low Velocity:
~ -10,000 km s^{-1}

Wider Lines With Higher Velocity

Measure Silicon Velocity



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Wider Lines With Higher Velocity

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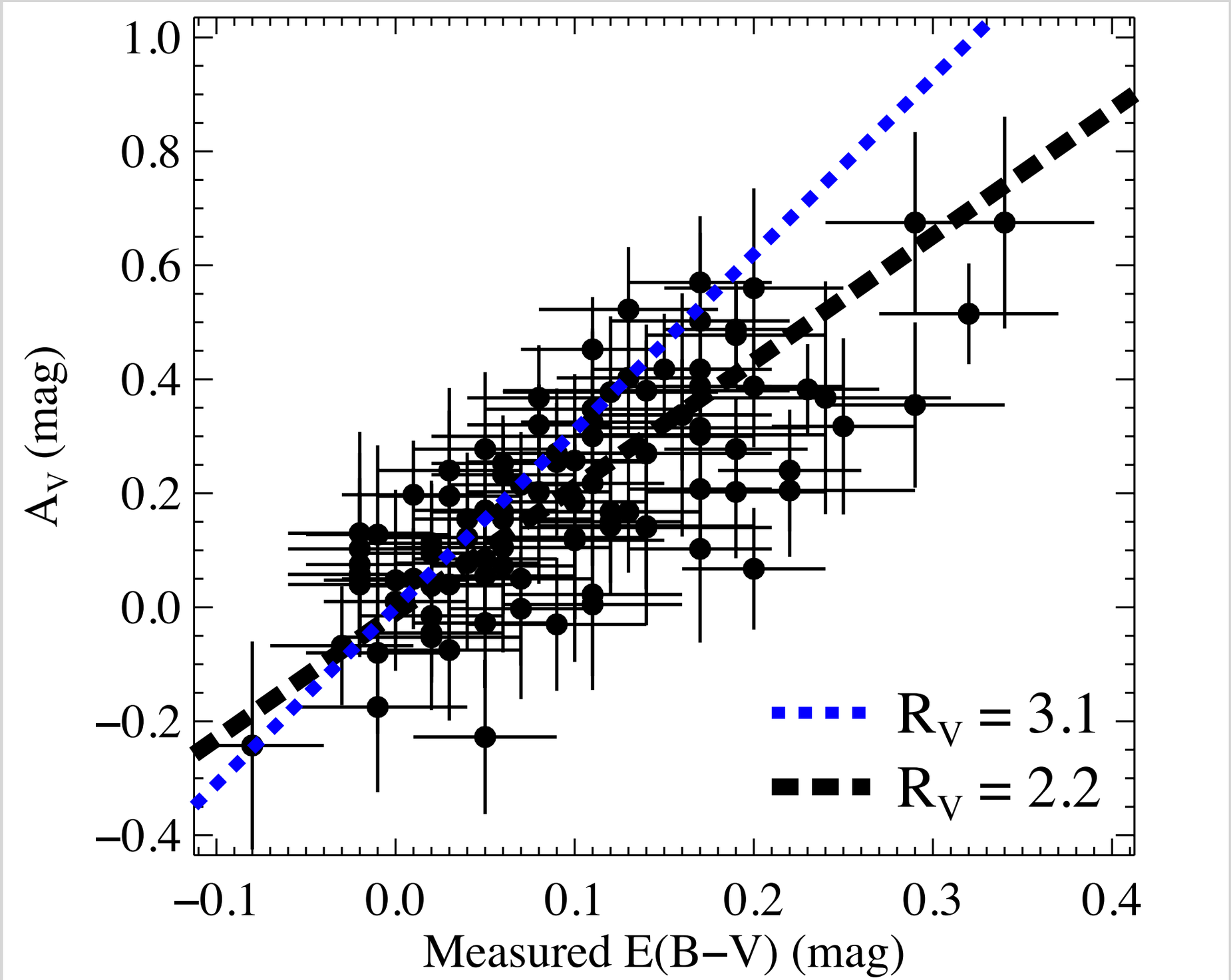
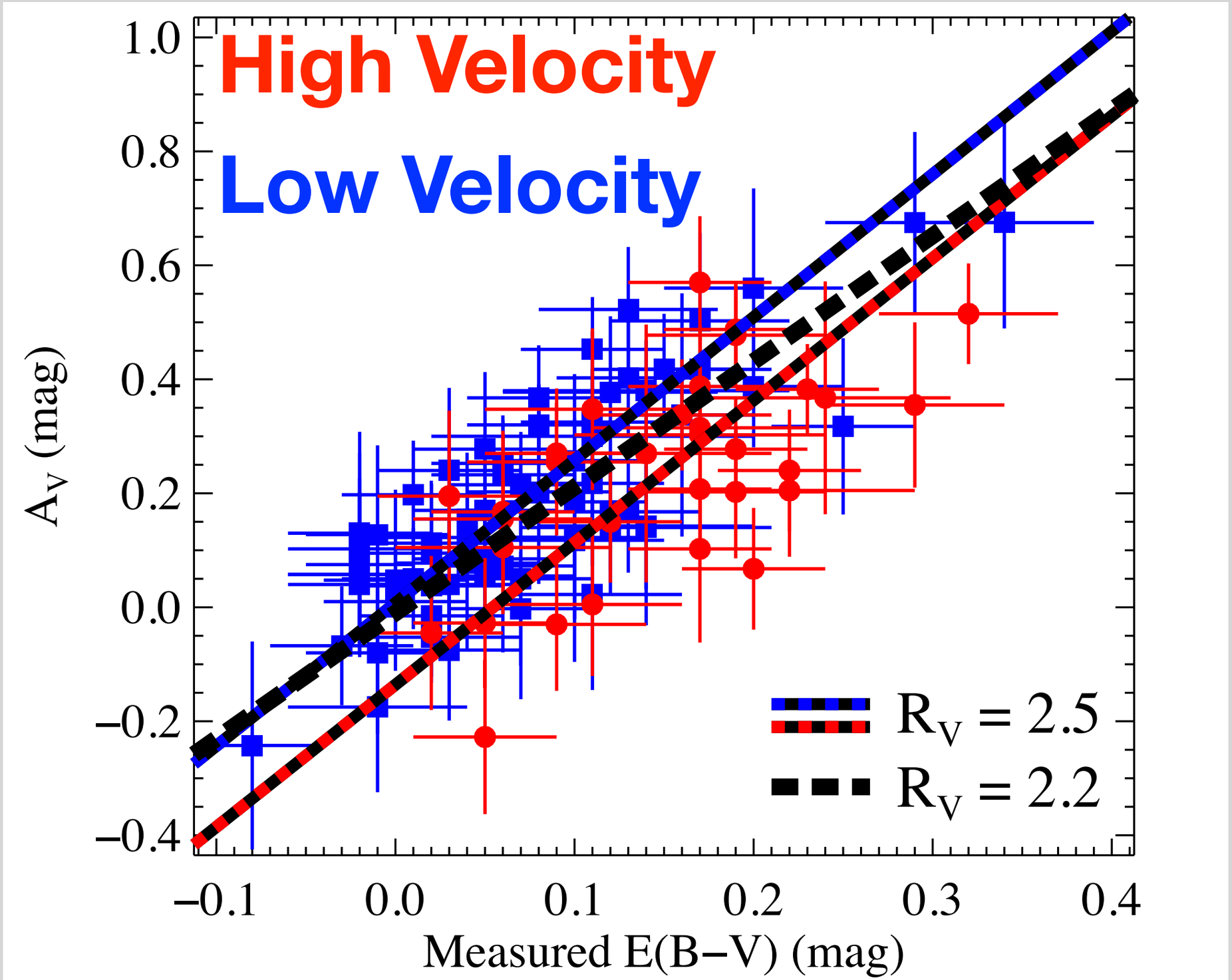


R_V = A_V/E(B-V)

Foley & Kasen 2011

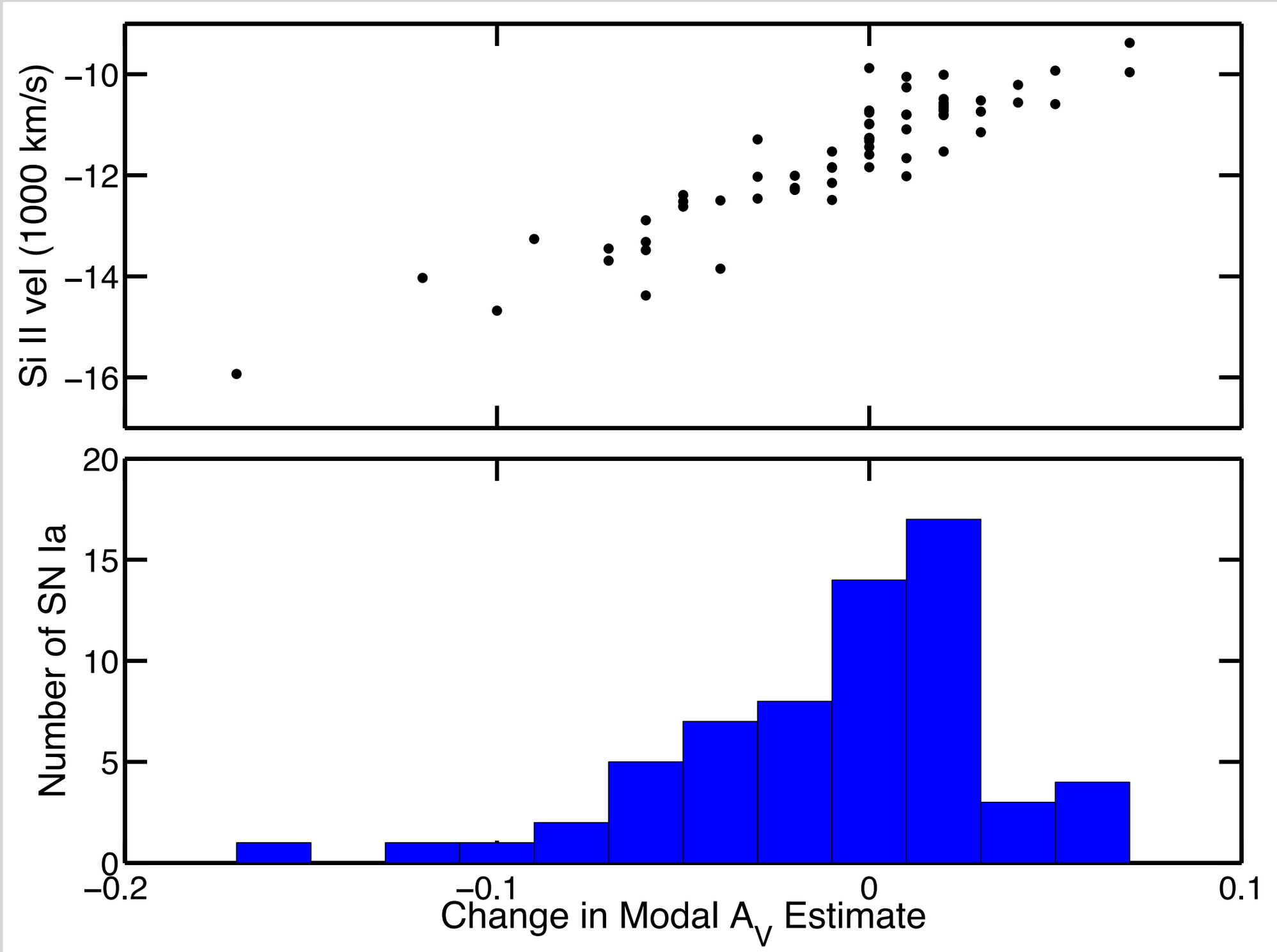
Intrinsic Color Depends on SN Velocity



R_V = A_V/E(B-V)

Foley & Kasen 2011
also Foley 2012; Foley, Sanders, & Kirshner 2011; Mandel, Foley, & Kirshner 2014

Intrinsic Color Depends on SN Velocity



Mandel, Foley, & Kirshner 2014

Ejecta Velocity is the "Next Parameter"

Low Velocity

High Velocity

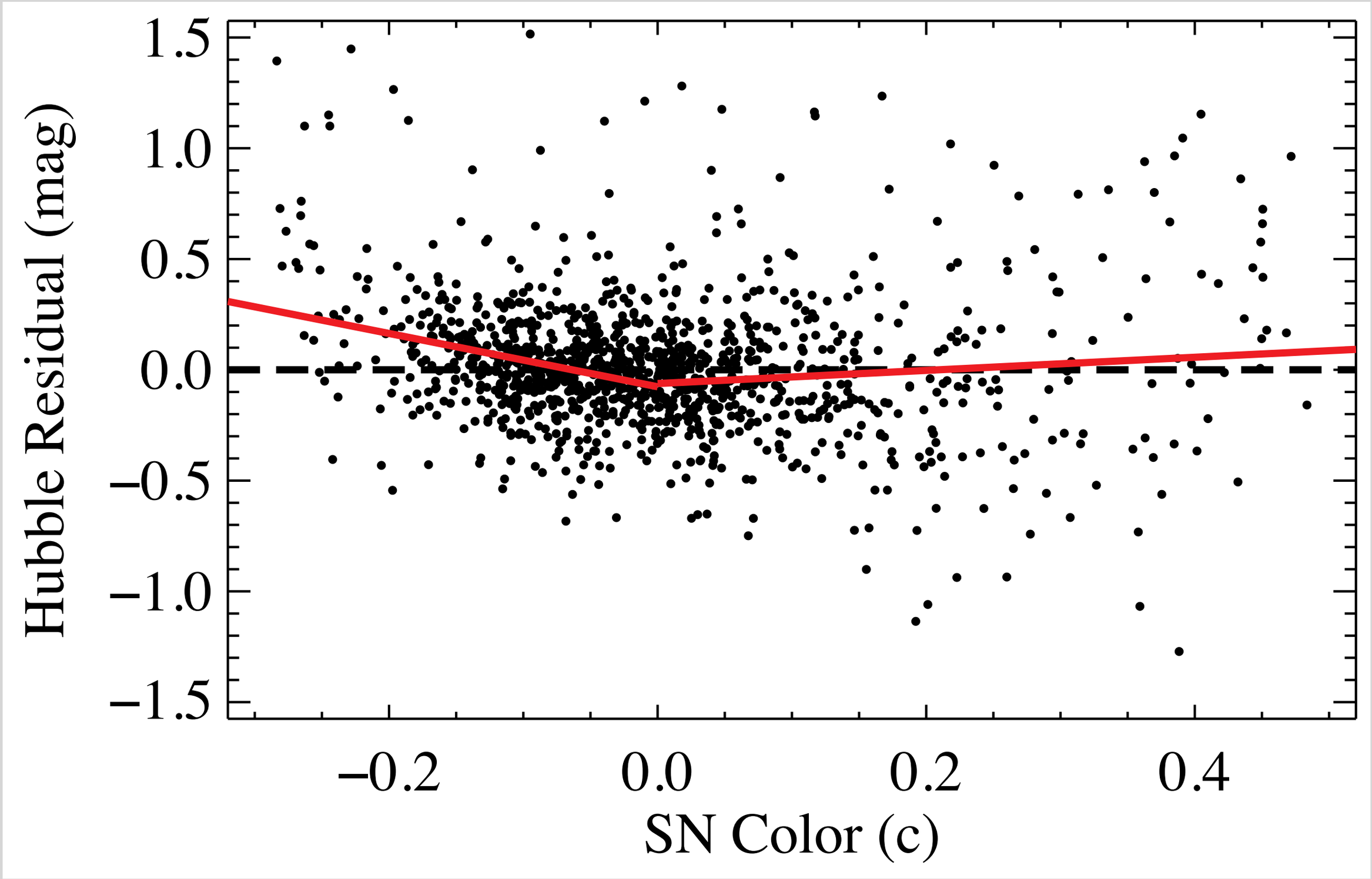
Ejecta Velocity is the “Next Parameter”

Velocity Improves Precision by 2.4x *and* Reduces Bias

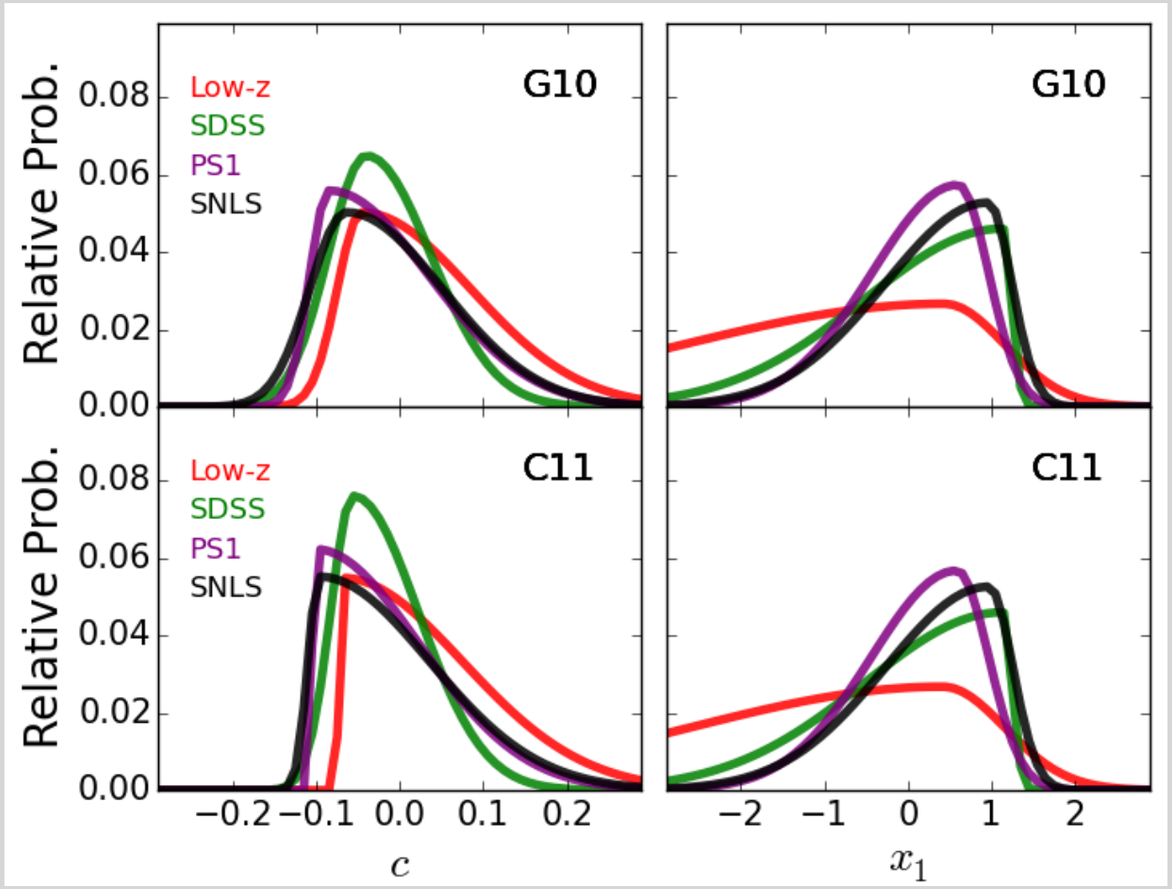
Low Velocity

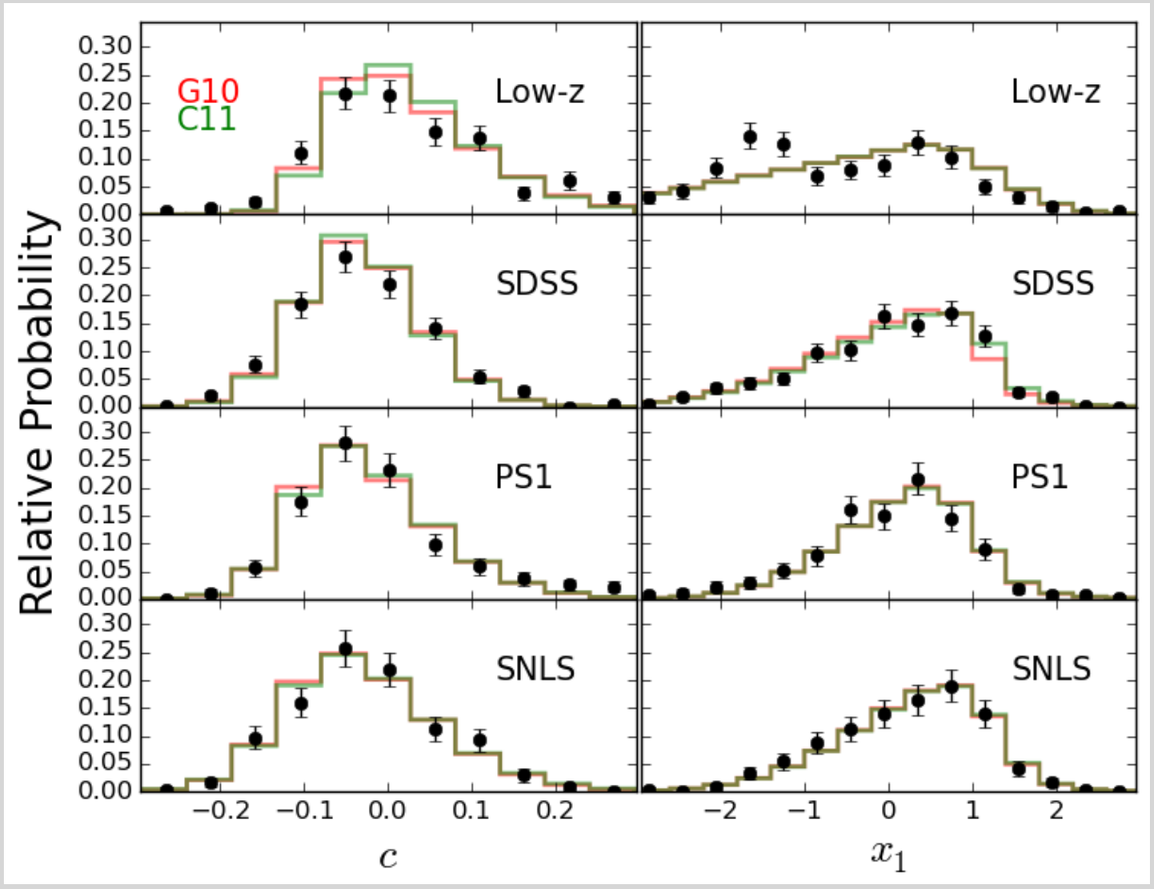
High Velocity

Evidence for Two Color Components



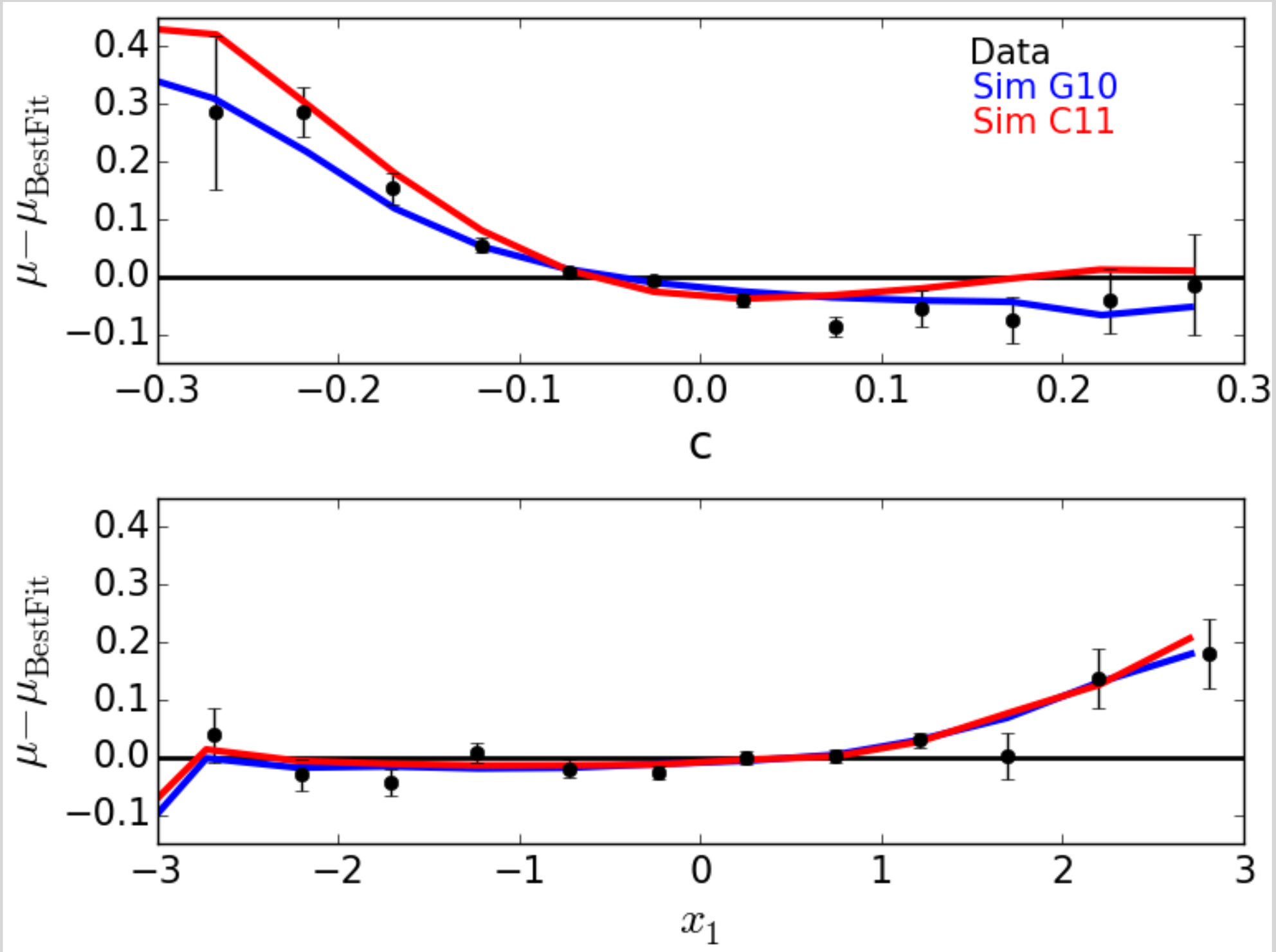
Populations from Simulations





Scolnic & Kessler 2016

Simulations Predict (Remove) Biases



Scolnic & Kessler 2016