Weak Lensing for Precision Cosmology

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1 Notes

In this section I present some general notes on weak lensing.

1.1 Talk Structure:

1. Motivate The Problem Cosmo
2. Introduce The Theory Cosmo + Lensing
3. Explain How Theory Solves The Problem
4. Current Results/ Experiments
5. Explain Problems with WeakLensing
6. Summarise

1.1.1 Motivate The Problem

Discuss probing the large scale universe with CMB, supernvae, clustering and lensing. Note weak lensing makes no assumptions about the nature of dark matter and no assumptions about relationship between visible matter and mass therefore it provides a directly measured mass distribution in the universe as a function of redshift. Therefore we can get info on DE and DM directly. It is sensitive to intial conditions so it can even give info on inflation.

1.2 The Basics of Lensing Arxiv:0304438

1.3 Random Lecture

$$\vec{\beta} = \vec{\theta} - \vec{\alpha}(\vec{\theta}) \tag{1}$$

$$\vec{\alpha}(\vec{\theta}) = \frac{1}{\pi} \int d^2\theta' \kappa(\vec{\theta'}) \frac{\vec{\theta} - \vec{\theta'}}{|\vec{\theta} - \vec{\theta'}|^2} \tag{2}$$

1.3.1 Bending of Light

1.3.2 Newtonian Lens

Contrary to the common belief that bending of light is unique to GR, classical Newtonian mechanics actually allows for the bending of light. To illustrate this consider a mass M located at the origin of the cartesian plane and a particle propagating along the $x = b$ line. We note that there will occur some momentum transfer due to gravity. The particle starts off with momentum $(p, 0)$ and ends up with momentum (p_x, p_y). Therefore, the particle path is deflected by some angle $\Delta\theta$. The deflection angle is simply given by $\sin(\Delta\theta) = \frac{p_y}{\sqrt{p_x^2+p_y^2}}$.

For very small deflections we have $p \approx p_x >> p_y$ and $\Delta\theta << 1$. Therefore $\Delta\theta \approx \frac{p_y}{p_x}$. We can now consider the differntial effect on momentum in the y direction along the entire path. we have $\frac{dp_y}{p_x} = \frac{1}{px}dx\frac{dp_y}{dx}$. Therefore we can find the deflection angle by

$$\begin{aligned}\Delta\theta &= -\frac{1}{p_x}\int dx\frac{dp_y}{dx} \\ &= -\frac{1}{cp_x}\int dx\frac{dp_y}{dt} \\ &= \frac{2GM}{c^2 b}\end{aligned} \tag{3}$$

We note that the mass of the particle cancels out of the deflection equation. Therefore this equation applies for massless particles i.e. light. Therefore Equation 3 provides a newtonian description for the bending of light.

1.3.3 General Relativistic Bending of Light

2 General Introduction

Layman friendly descirption of cosmology + weak lensing and its purpose.

3 Cosmological Observables

Discussion about cosmology in general and observable in the framework [4].

4 Gravitational Lensing

Discussion about lensing as a whole then specifics [2] [3] [1]

References

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[2] Rachel Mandelbaum. Weak Lensing for Precision Cosmology. *Annual Review of Astronomy and Astrophysics*, 56:393–433, Sep 2018.

[3] Richard Massey, Henk Hoekstra, Thomas Kitching, Jason Rhodes, Mark Cropper, Jérôme Amiaux, David Harvey, Yannick Mellier, Massimo Meneghetti, Lance Miller, Stéphane Paulin-Henriksson, Sand rine Pires, Roberto Scaramella, and Tim Schrabback. Origins of weak lensing systematics, and requirements on future instrumentation (or knowledge of instrumentation). *mnras*, 429:661–678, Feb 2013.

[4] David H. Weinberg, Michael J. Mortonson, Daniel J. Eisenstein, Christopher Hirata, Adam G. Riess, and Eduardo Rozo. Observational probes of cosmic acceleration. *physrep*, 530:87–255, Sep 2013.