Weak Lensing for Precision Cosmology

Mohamed Shaaban

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1 General Introduction

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

2 Theory

2.1 Notes

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

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.

2.2 Bending of Light

The fundamental concept on which weak lensing is built is gravity's ability to alter the path of a photon. In this section we review the theory behind the bending of light necessary to develop the weak lensing formalism.

2.2.1 Newtonian Lens

It is a common misconception that the gravitational bending of light is an exclusive property of GR. However, gravity induced alterations to a photon's path are predicted by newtonian mechanics [5]. To illustrate this consider a mass M located at the origin of the cartesian plane and a corpuscle(newtonian photon) propagating along the $x = b$ line. Newton's second law predicts that the presence of the point mass will result in a momentum transfer between the two objects. If the corpuscle starts with momentum $(p, 0)$ then it will end 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

$$\sin(\Delta\theta) = \frac{p_y}{\sqrt{p_x^2 + p_y^2}} \tag{1}$$

For very small deflections we have $p \approx p_x >> p_y$ and $\Delta\theta << 1$. Therefore Equation 1 simplifies to $\Delta\theta \approx \frac{p_y}{p_x}$. We now consider the infinitesimal deflection along the entire path of the photon with $d\Delta\theta = \frac{dp_y}{p_x} = \frac{1}{px} dx \frac{dp_y}{dx}$. Therefore, we can find the deflection angle by

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

We note that the mass of the corpuscle cancels out of the deflection equation. Therefore this equation applies for massless particles i.e. photons. Therefore Equation 2 provides a newtonian description for the bending of light [5].

2.2.2 General Relativistic Bending of Light

The Einstein's field equations in the presence of a charge free point mass is uniquely solved by the Schwarzchild Metric [].

$$\Delta\theta = 2\Delta\theta_N = \frac{4GM}{c^2 b} \tag{3}$$

2.3 Lensing Formalism

[2] Cosmology standard model and lensing formalism

3 Cosmological Observables

Discussion about cosmology in general and observable in the framework [6].

4 Weak Gravitational Lensing

Discussion about lensing as a whole then specifics [3] [4] [1]

5 Problems With Weak Lensing

6 Weak Lensing Results

References

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