Advanced Gravitational Physics

Tommaso Peritore 67043A

February 10, 2026

Contents

1 Gravitational Waves

1.1 Equations of motion

1.2 Solution and resonant frequency

1.3 System energy and radiated energy

1.4 $h_\times$ wave

1.5 Example and detection prospects

2 Cosmology

2.1 Equations from Section 13.3 - Dodelson&Schmidt

Eq.13.19 - Lensing deflection angle

The lensing deflection angle $\Delta\boldsymbol{\theta}$ is related to the lensing potential ϕ_L by:

$$\Delta\boldsymbol{\theta}(\mathbf{l}) = i\,\ell\,\phi_L(\mathbf{l}), \tag{1}$$

which is Dodelson's Eq.13.19, which we can verify starting from the real-space relation:

$$\Delta\theta^i(\boldsymbol{\theta}) = \frac{\partial}{\partial\theta^i}\phi_L(\boldsymbol{\theta}), \tag{2}$$

having defined the lensing potential as:

$$\phi_L(\boldsymbol{\theta}) \equiv 2\int_0^{\chi} \frac{d\chi'}{\chi'}\Phi(\mathbf{x}(\boldsymbol{\theta},\chi'))(1-\chi'/\chi). \tag{3}$$

see Fourier $f(\mathbf{l}) \to e^{-i\mathbf{l}\cdot\boldsymbol{\theta}} f(\boldsymbol{\theta})$; $f(\boldsymbol{\theta}) \to \frac{e^{i\mathbf{l}\cdot\boldsymbol{\theta}}}{(2\pi)^2} f(\mathbf{l})$
$\phi_L(\boldsymbol{\theta}) = \int \frac{d^2l}{(2\pi)^2}\phi_L(\mathbf{l})\, e^{i\mathbf{l}\cdot\boldsymbol{\theta}}$; $\Delta\theta^i(\boldsymbol{\theta}) = \int \frac{d^2l}{(2\pi)^2}\Delta\theta^i(\mathbf{l})\, e^{i\mathbf{l}\cdot\boldsymbol{\theta}}$
from $\Delta\theta^i(\boldsymbol{\theta}) = \frac{\partial}{\partial\theta^i}\phi_L(\boldsymbol{\theta})$ sub $\phi_L(\boldsymbol{\theta})$ w/ F

$$= \frac{\partial}{\partial\theta^i}\int \frac{d^2l}{(2\pi)^2}\phi_L(\mathbf{l})\, e^{i\mathbf{l}\cdot\boldsymbol{\theta}} = \int \frac{d^2l}{(2\pi)^2}\, il^i\, \phi_L(\mathbf{l})\, e^{i\mathbf{l}\cdot\boldsymbol{\theta}}$$

comparing $\Delta\boldsymbol{\theta}(\mathbf{l}) = i\mathbf{l}\,\phi_L(\mathbf{l})$

2.2 Exercise 13.7 - Dodelson&Schmidt

2.3 CMB Polarization