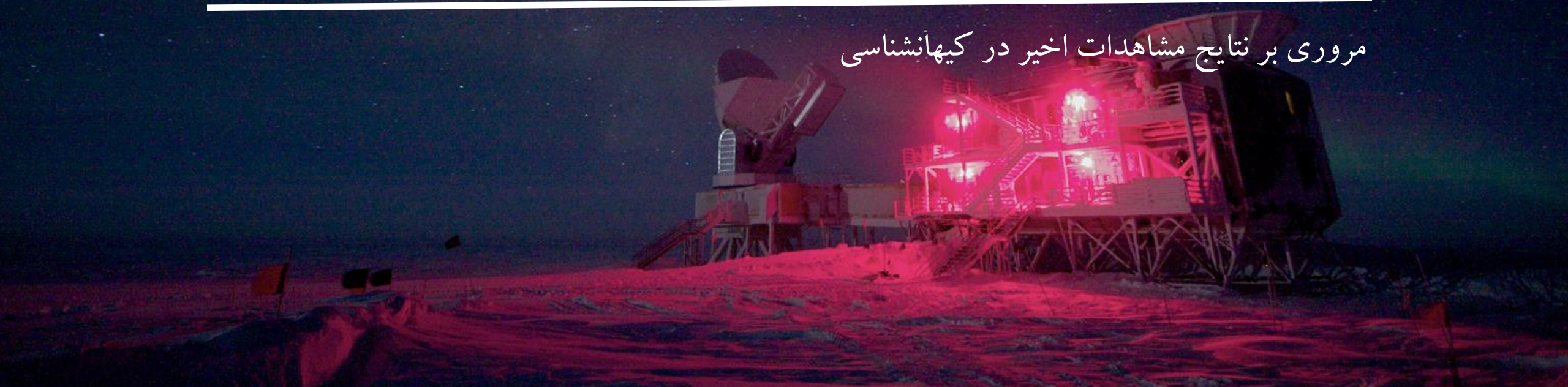


کنفرانس بهاره فیزیک
اردیبهشت نود و سه
پژوهشگاه دانش های بنیادی



تصویر طفولیت کیهان

مروری بر نتایج مشاهدات اخیر در کیهانشناسی



The South Pole is the closest you can get to space and still be on the ground. It's one of the driest and clearest locations on Earth, perfect for observing the faint microwaves from the Big Bang.“

John Kovac, the Harvard-Smithsonian Center for Astrophysics in Massachusetts, and leader of the Background Imaging of Cosmic Extragalactic Polarization (BICEP) collaboration

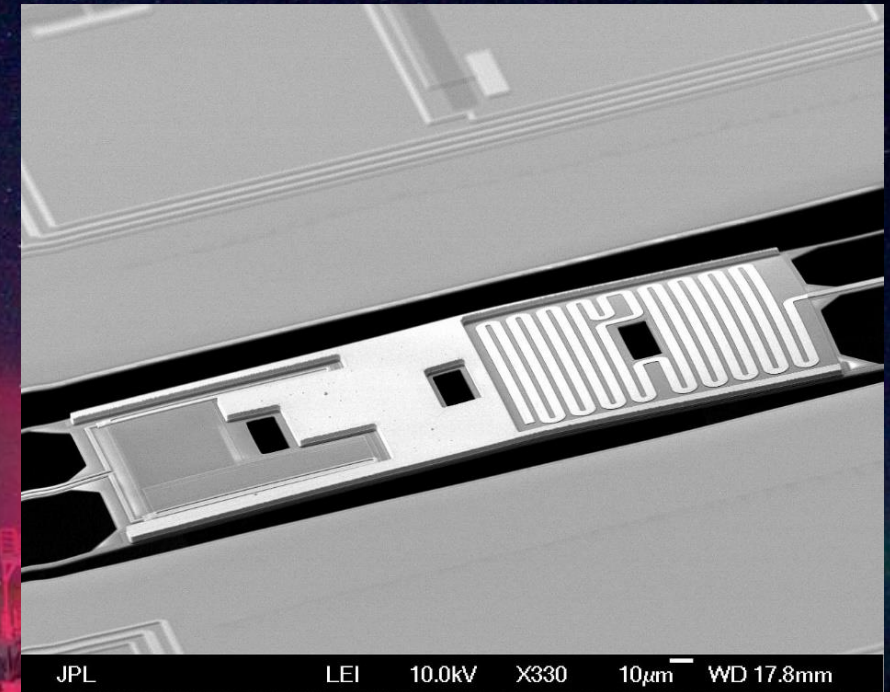
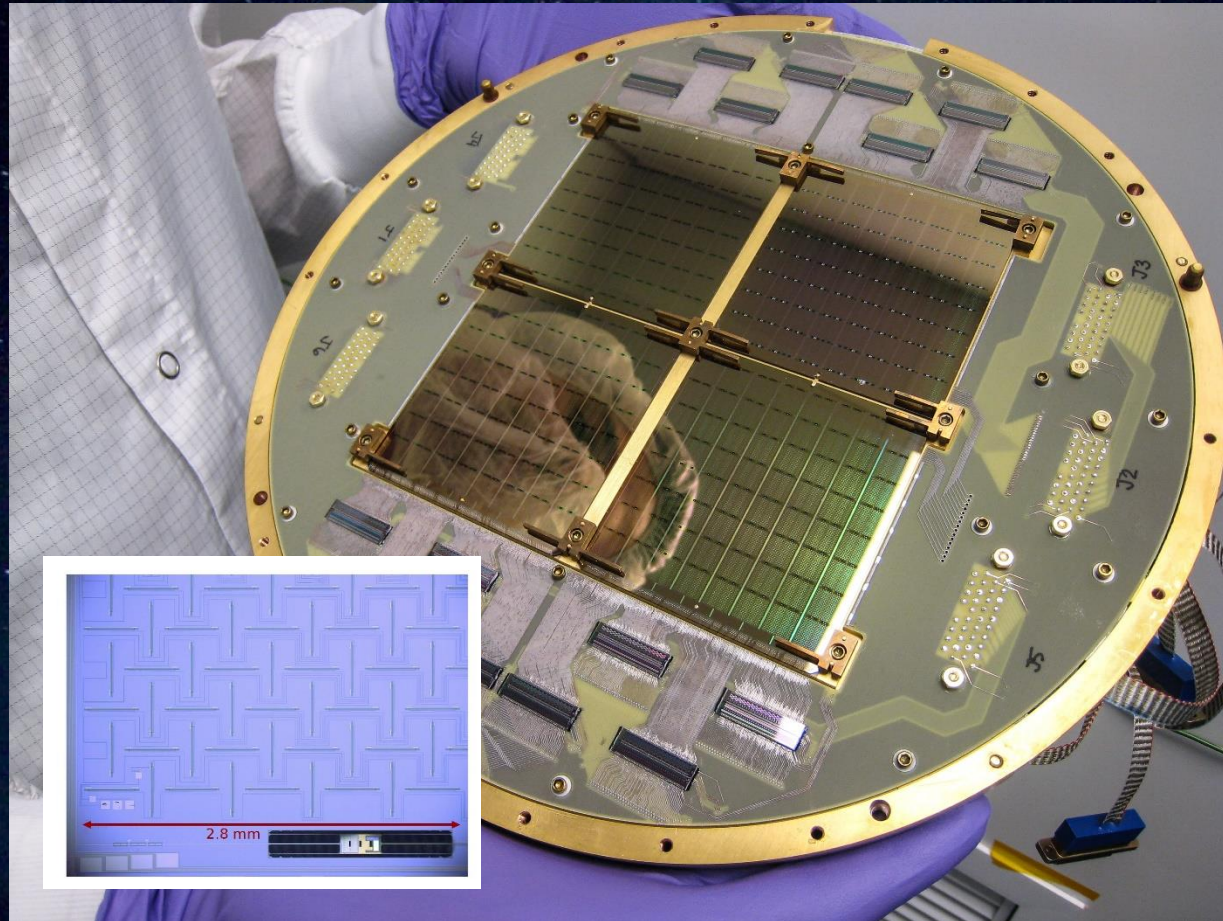
شرایط کار دشوار



تصویر طفولیت کیهان

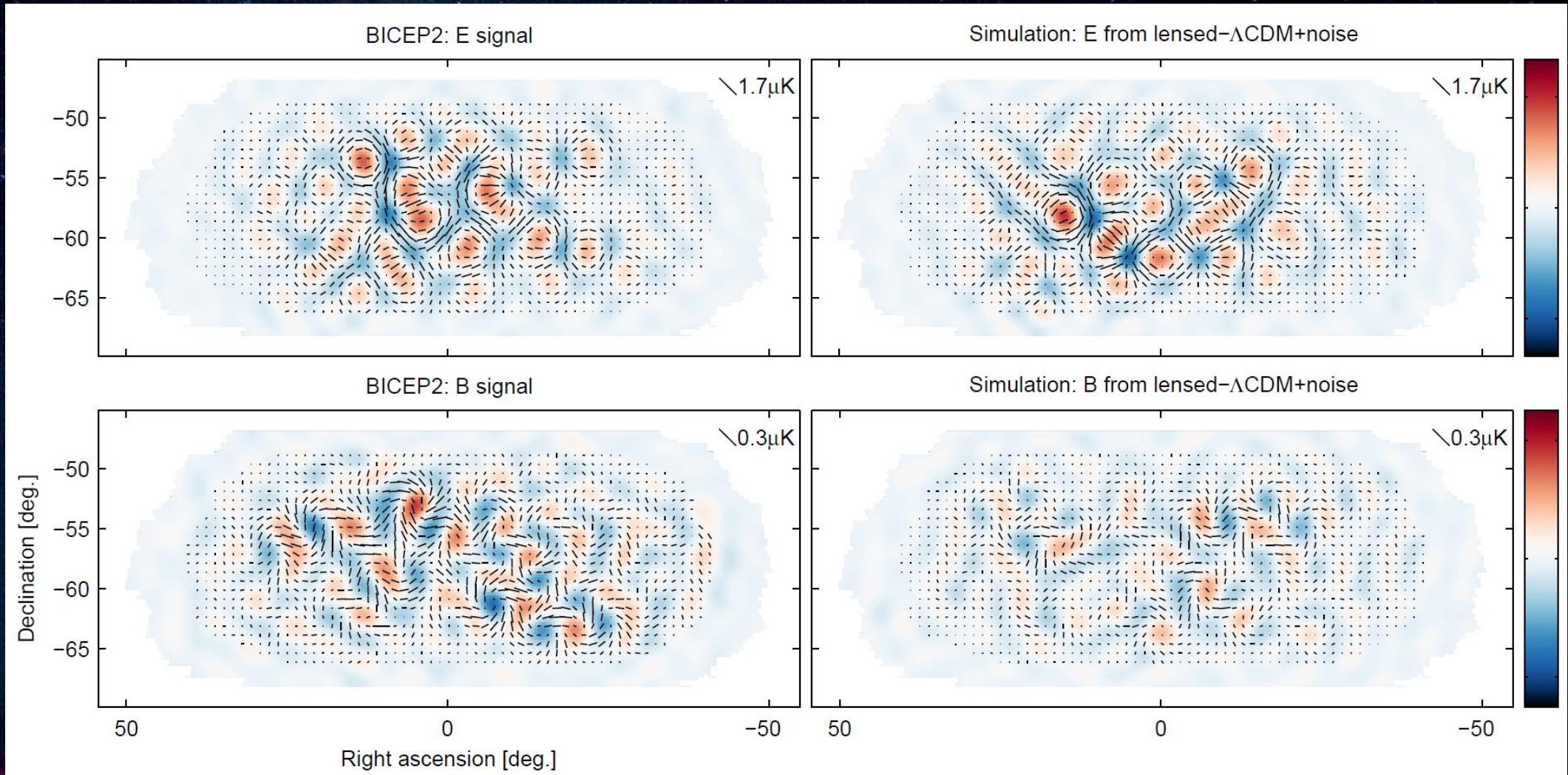
علی اکبر ابوالحسنی

آشکار سازها



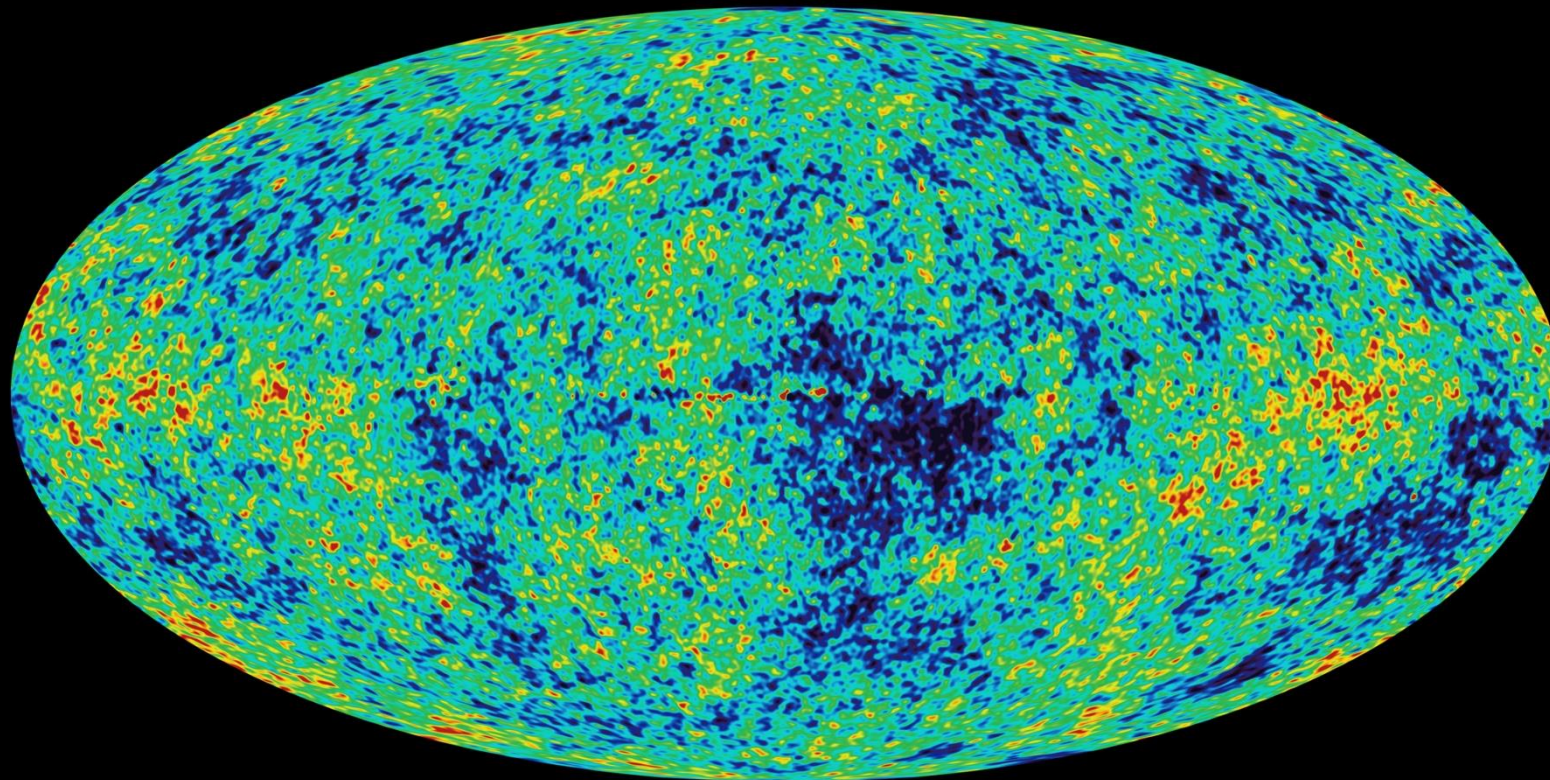
تصویر طفولیت کیهان

علی اکبر ابوالحسنی



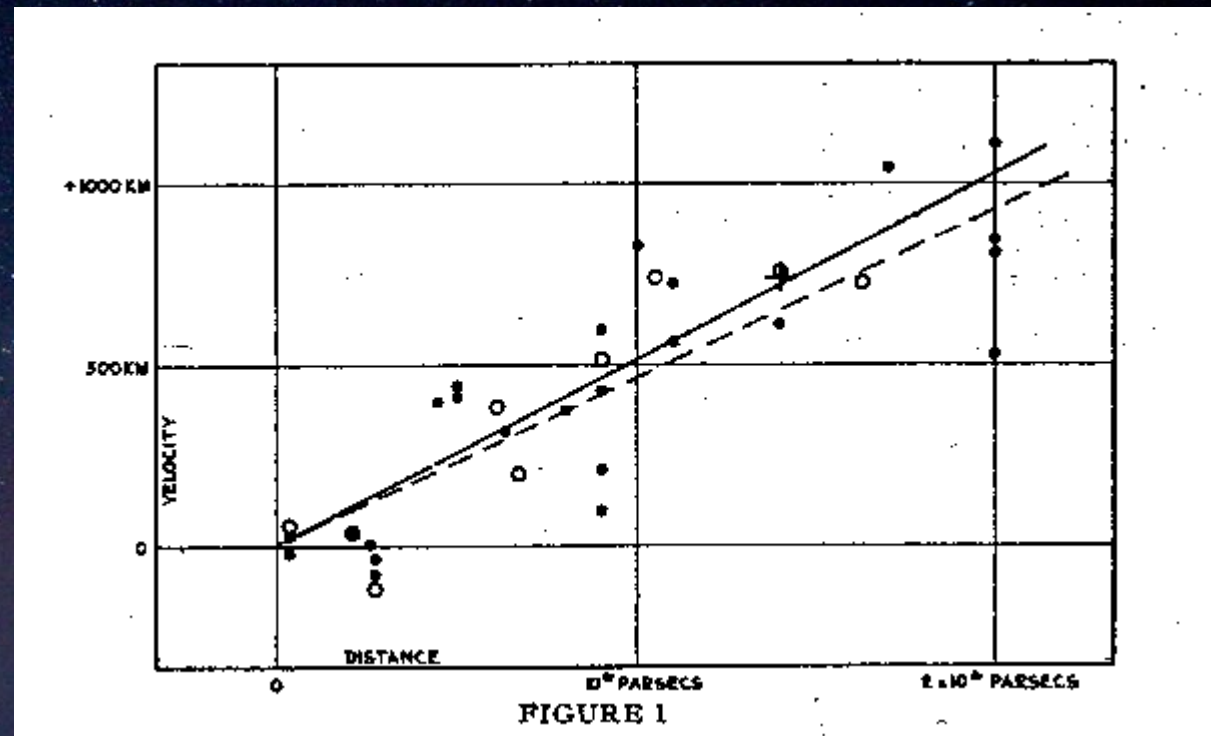


COBE

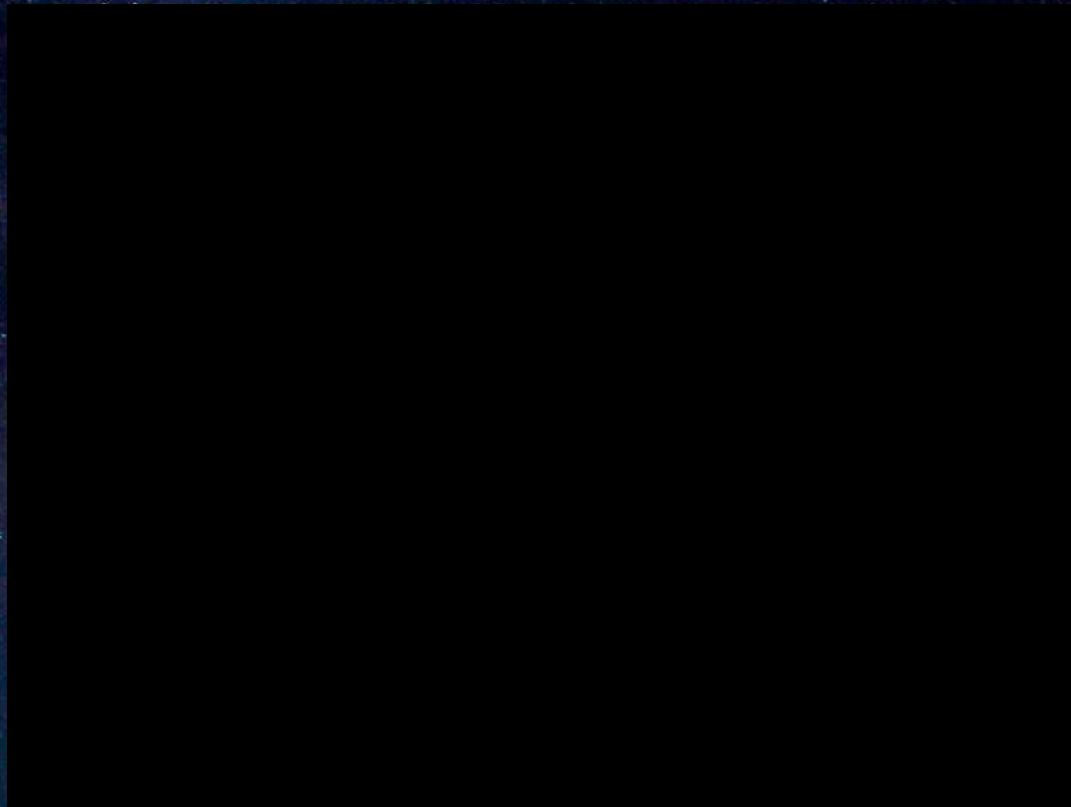


تصویر طفولیت کیهان

علی اکبر ابوالحسنی



انتقال به سرخ کیهانی



تصویر طفولیت کیهان

علی اکبر ابوالحسنی



Ralph Alpher



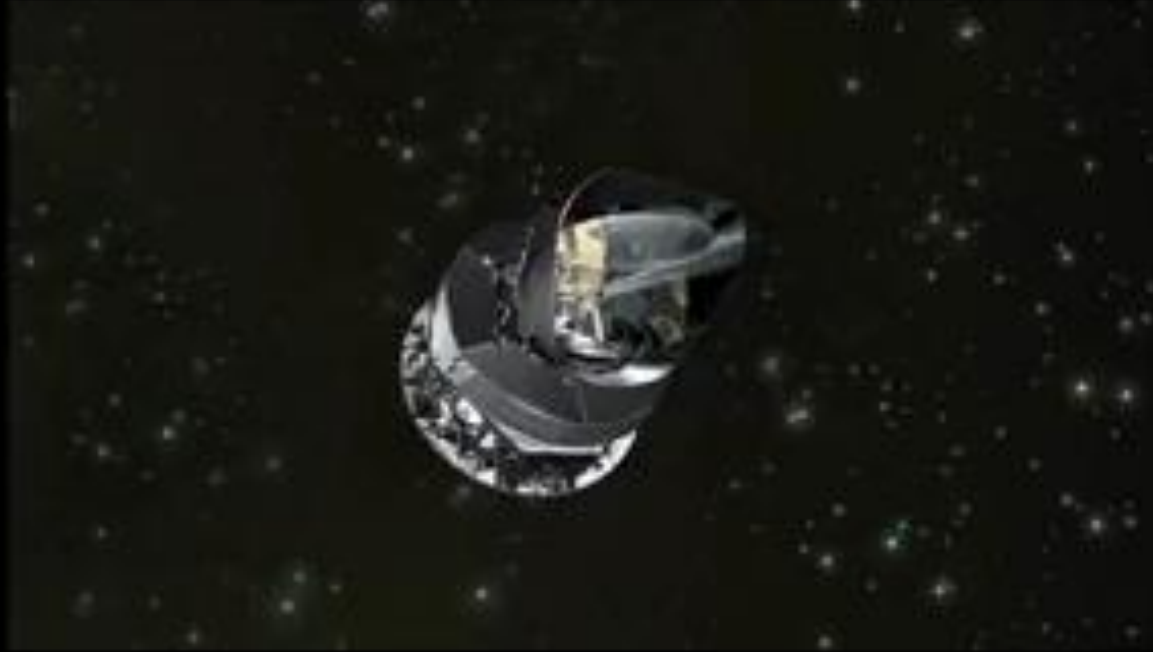
Hans Bethe



George Gamov

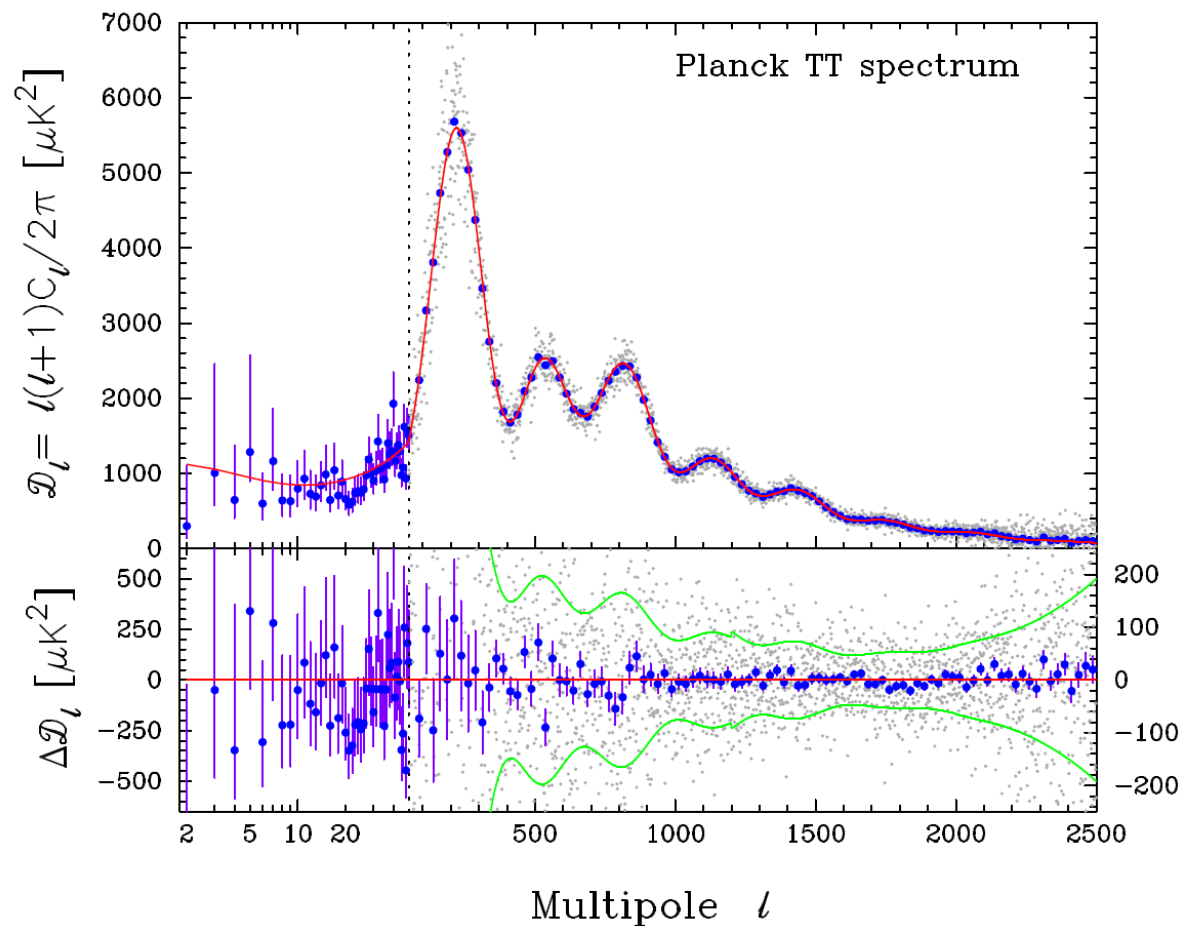
α β γ

A Journey of Light



through Space and Time

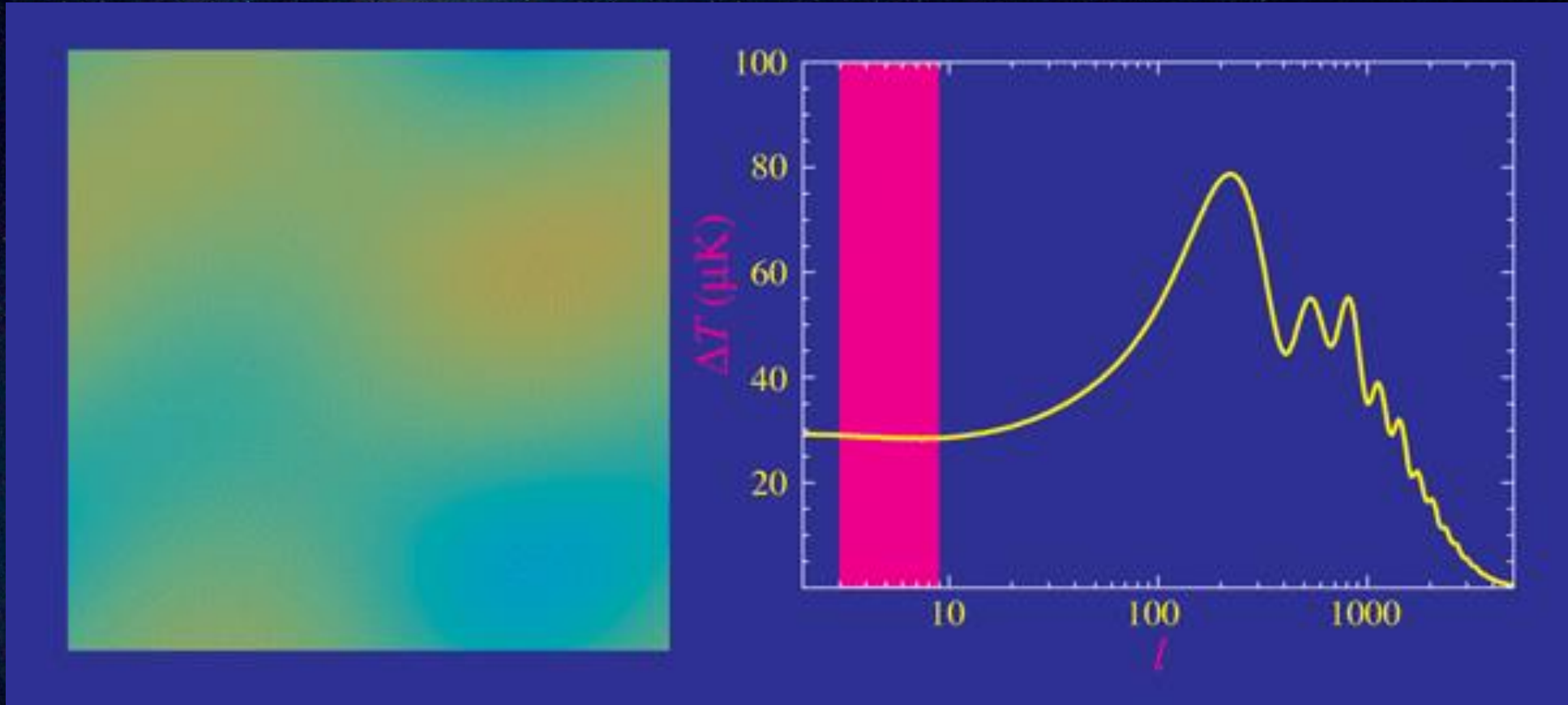




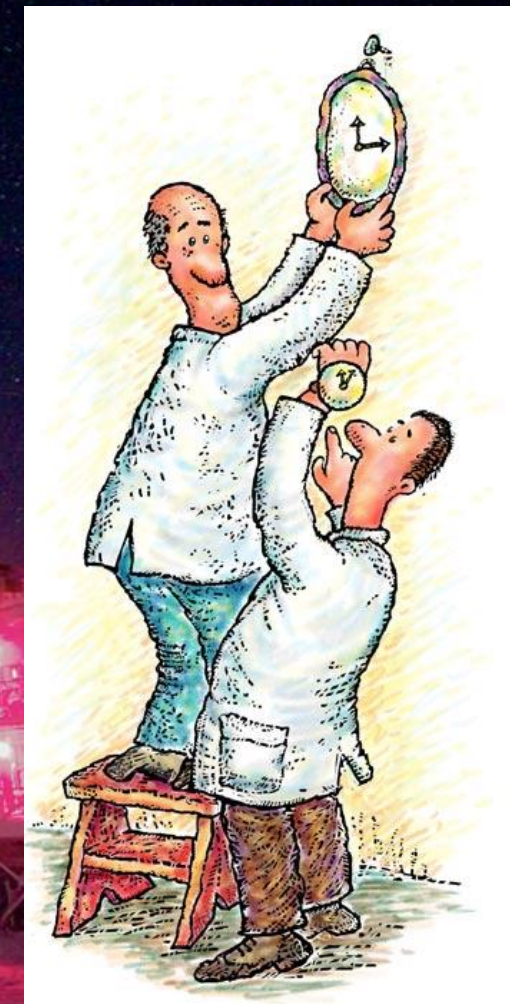
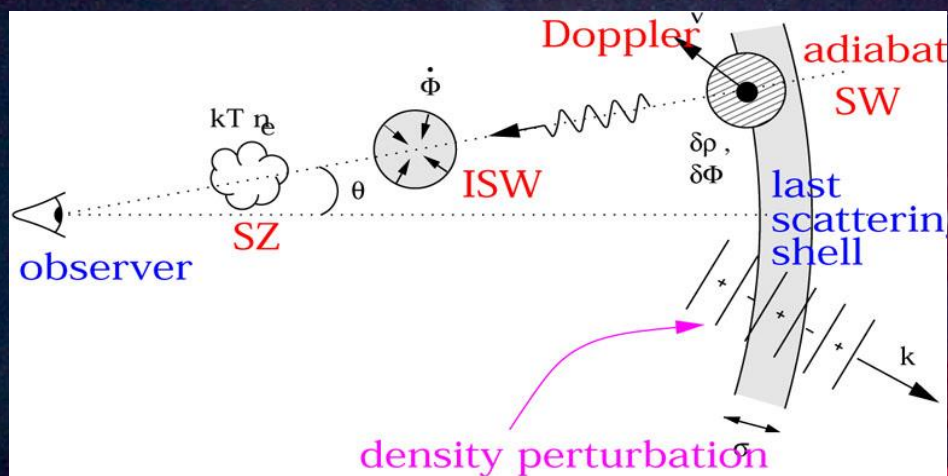
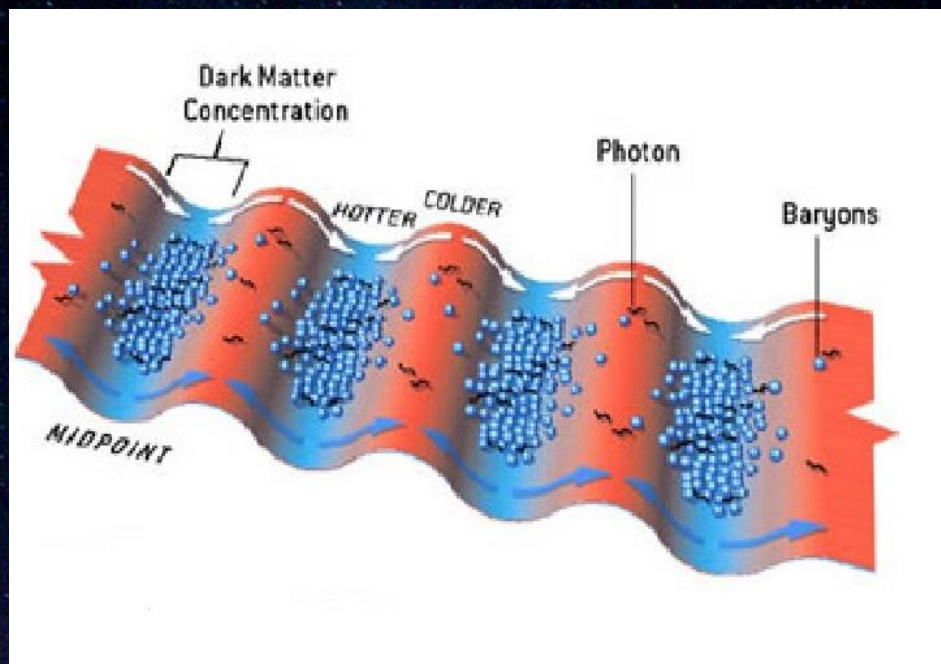
$$\frac{\delta T}{T_0}(\theta, \phi) = \sum a_{\ell m} Y_{\ell m}(\theta, \phi)$$

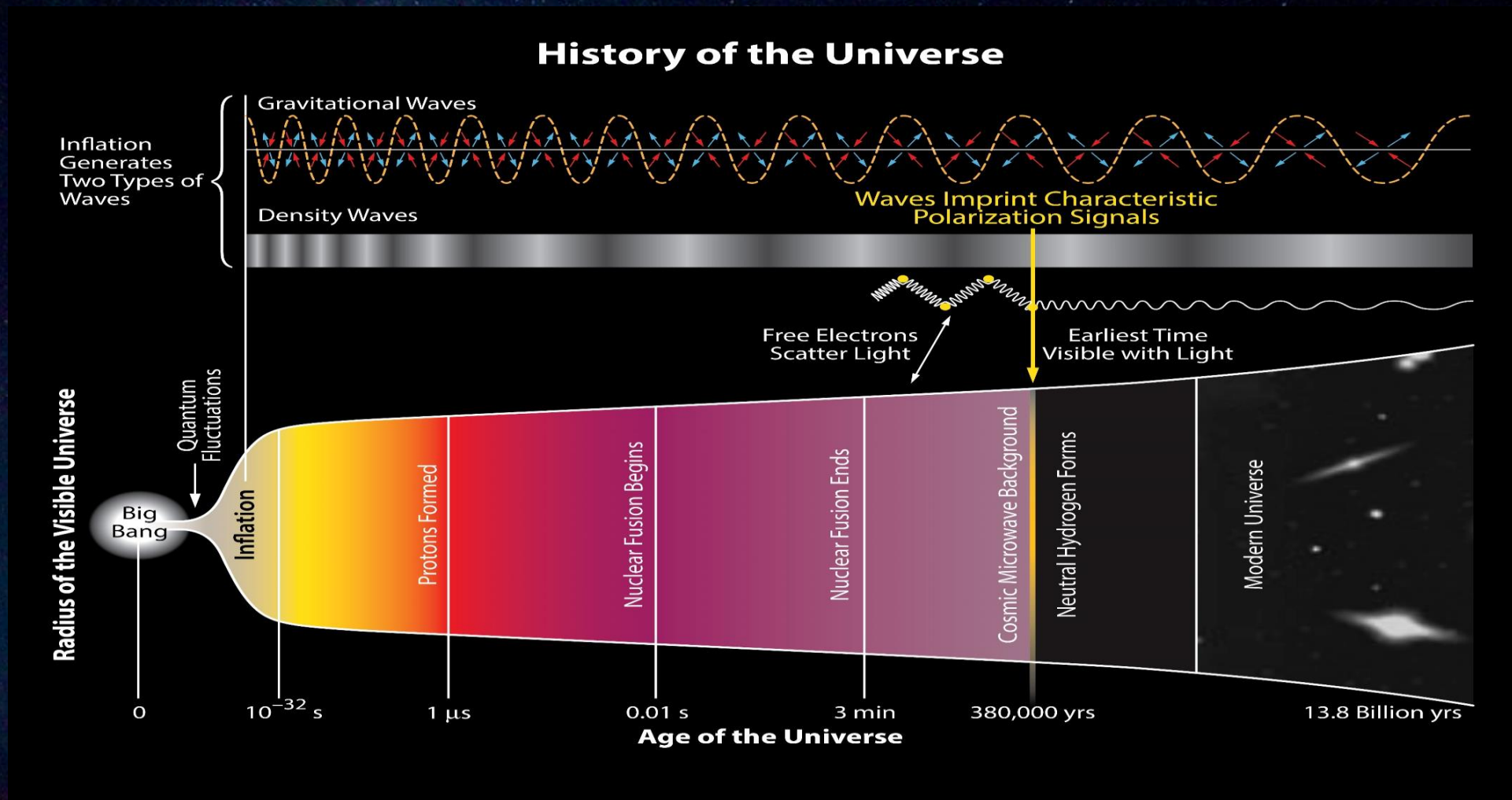
$$\langle a_{\ell m} a_{\ell' m'}^* \rangle = \delta_{\ell \ell'} \delta_{m m'} C_\ell$$

$$\vartheta_\lambda = \frac{2\pi}{\ell} = \frac{360^\circ}{\ell}.$$



سطح آخرین پراکندگی





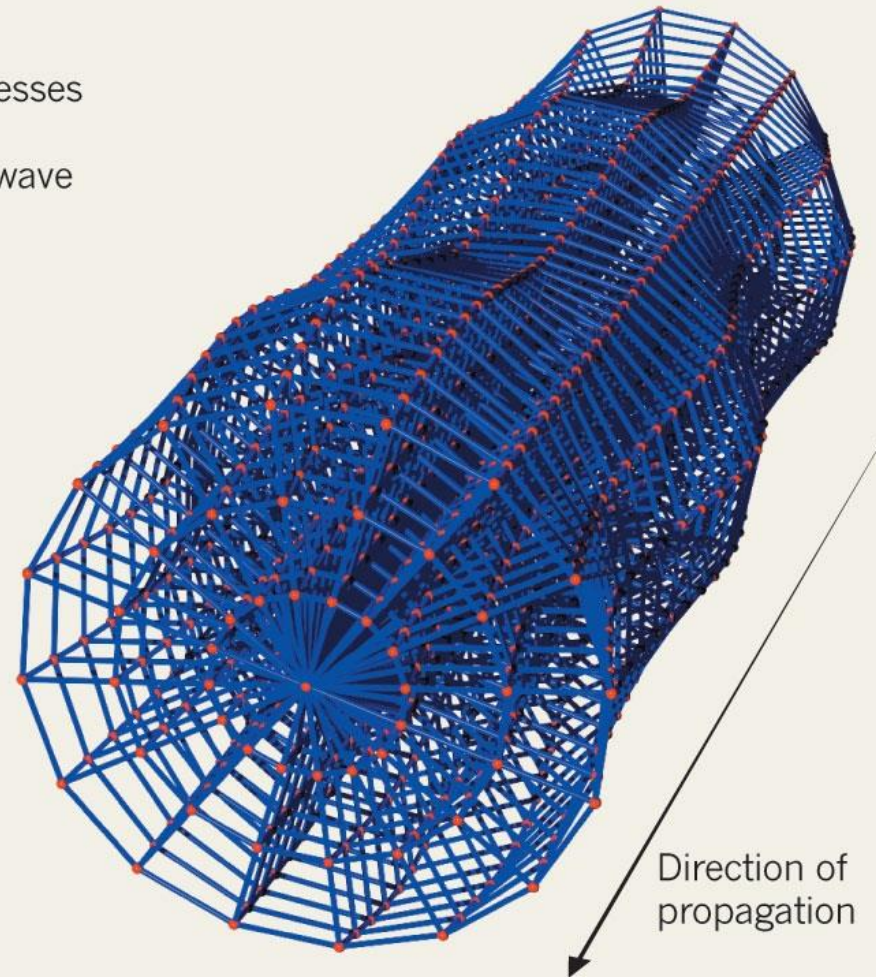
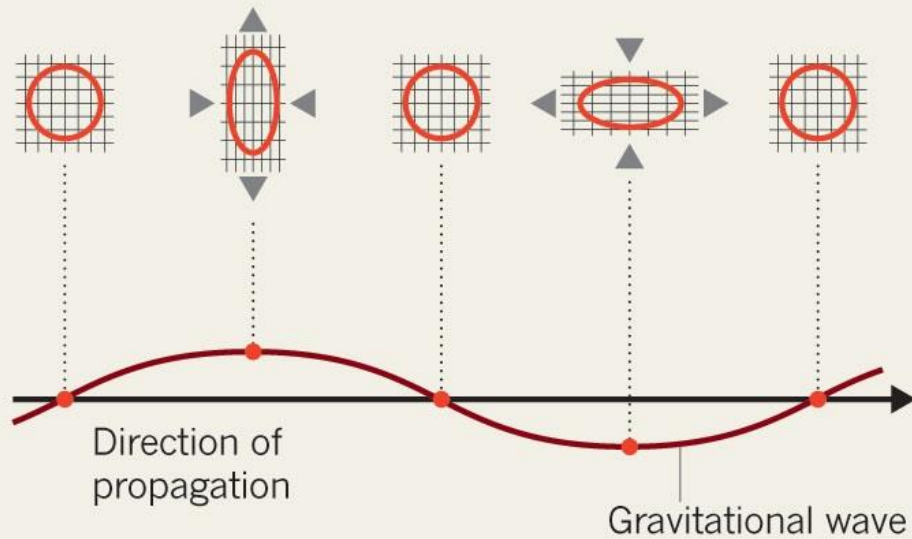
$$\langle \mathcal{R}_{\mathbf{k}} \mathcal{R}_{\mathbf{k}'} \rangle = (2\pi)^3 \delta(\mathbf{k} + \mathbf{k}') P_{\mathcal{R}}(k)$$

• افت و خیزهای نرده ای

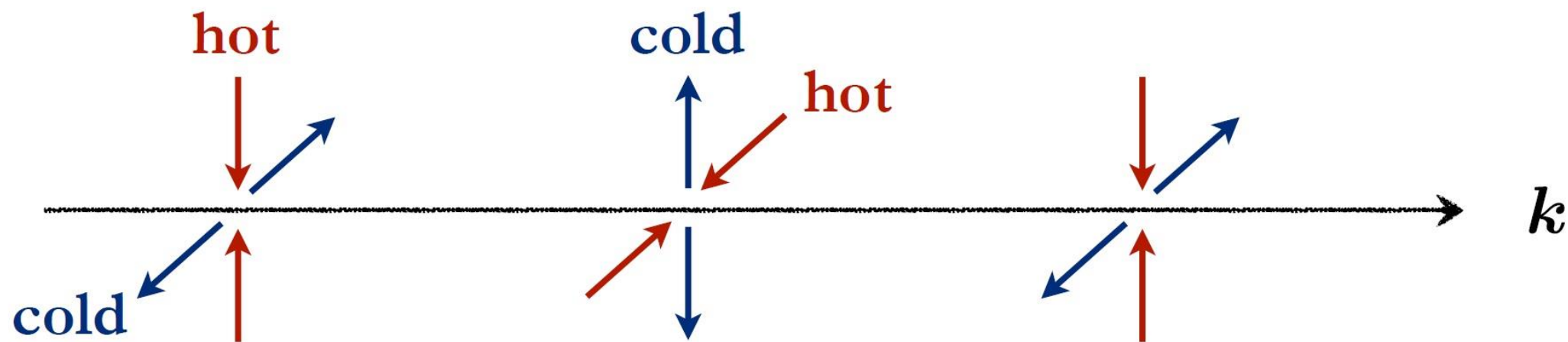
$$n_{\mathcal{R}} - 1 \equiv \left. \frac{d \ln \mathcal{P}_{\mathcal{R}}}{d \ln k} \right|_{k=aH}$$

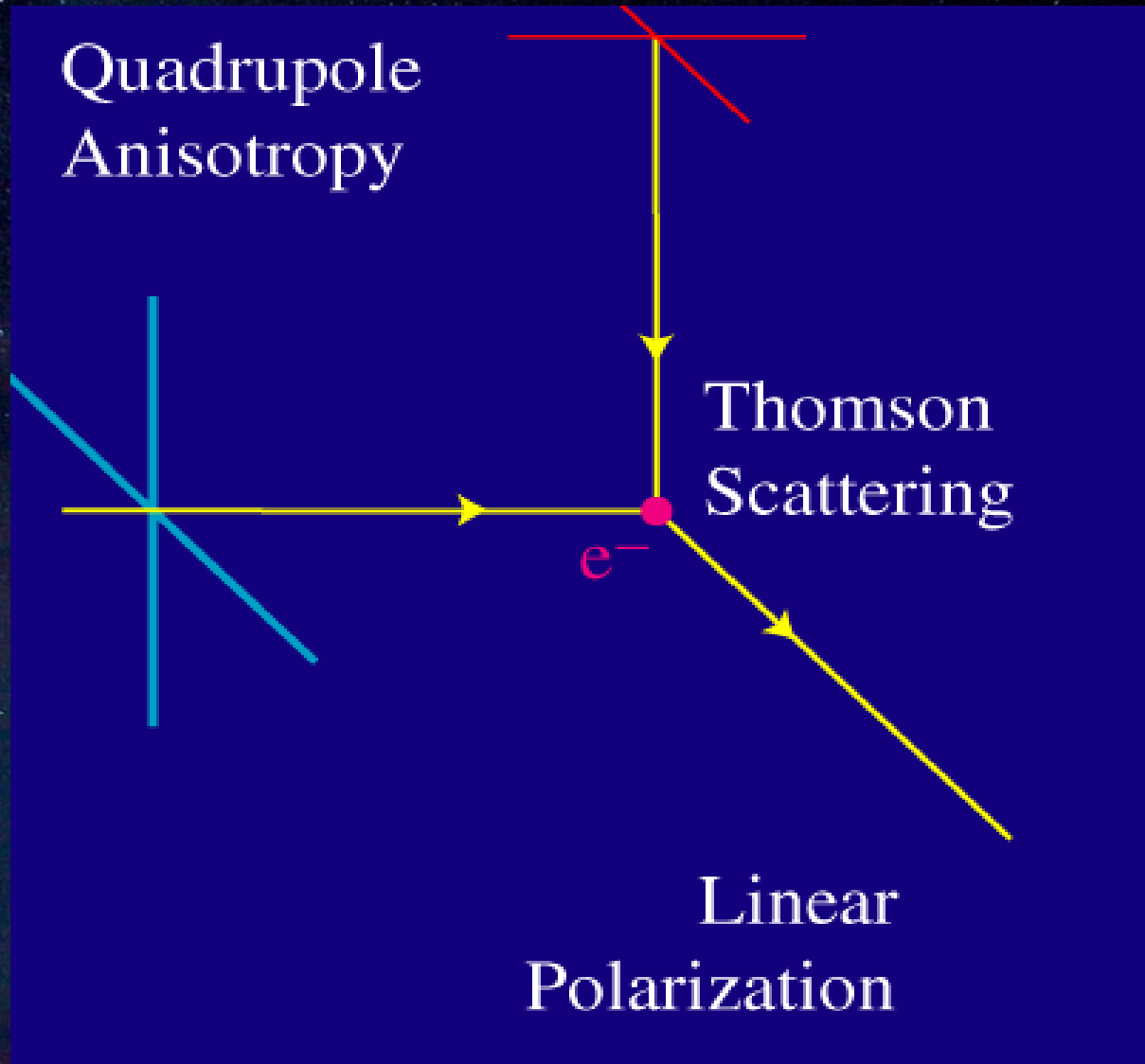
RIPPLE EFFECT

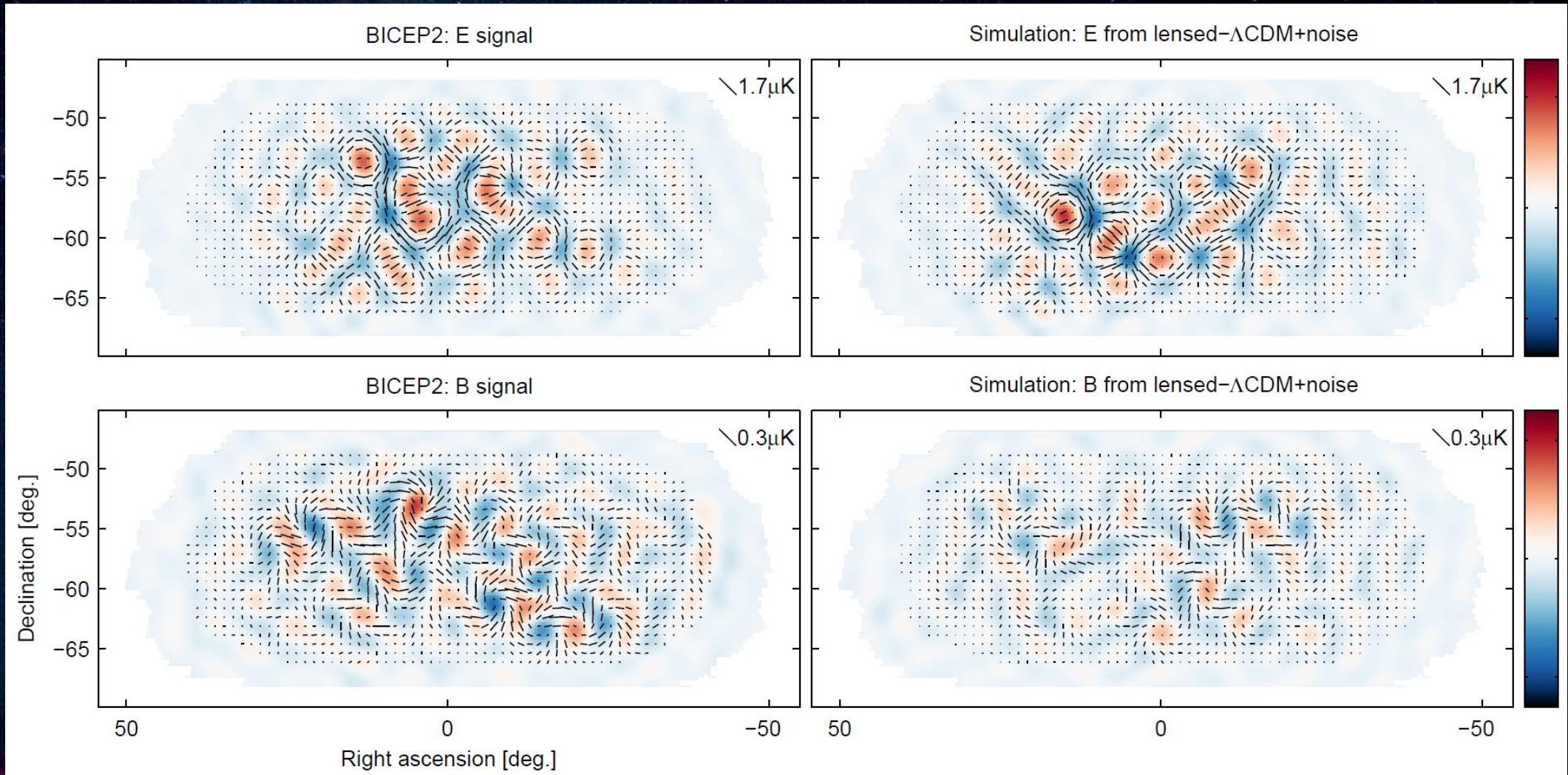
When a gravitational wave passes through space, it compresses it in one direction and stretches it in another, both at right angles to the wave's direction (red line). The effects of the wave moving along a blue tube are shown.



$$P_T(k) \equiv r P_S(k) = \frac{2H(k)^2}{\pi^2 M_{Pl}^2}$$

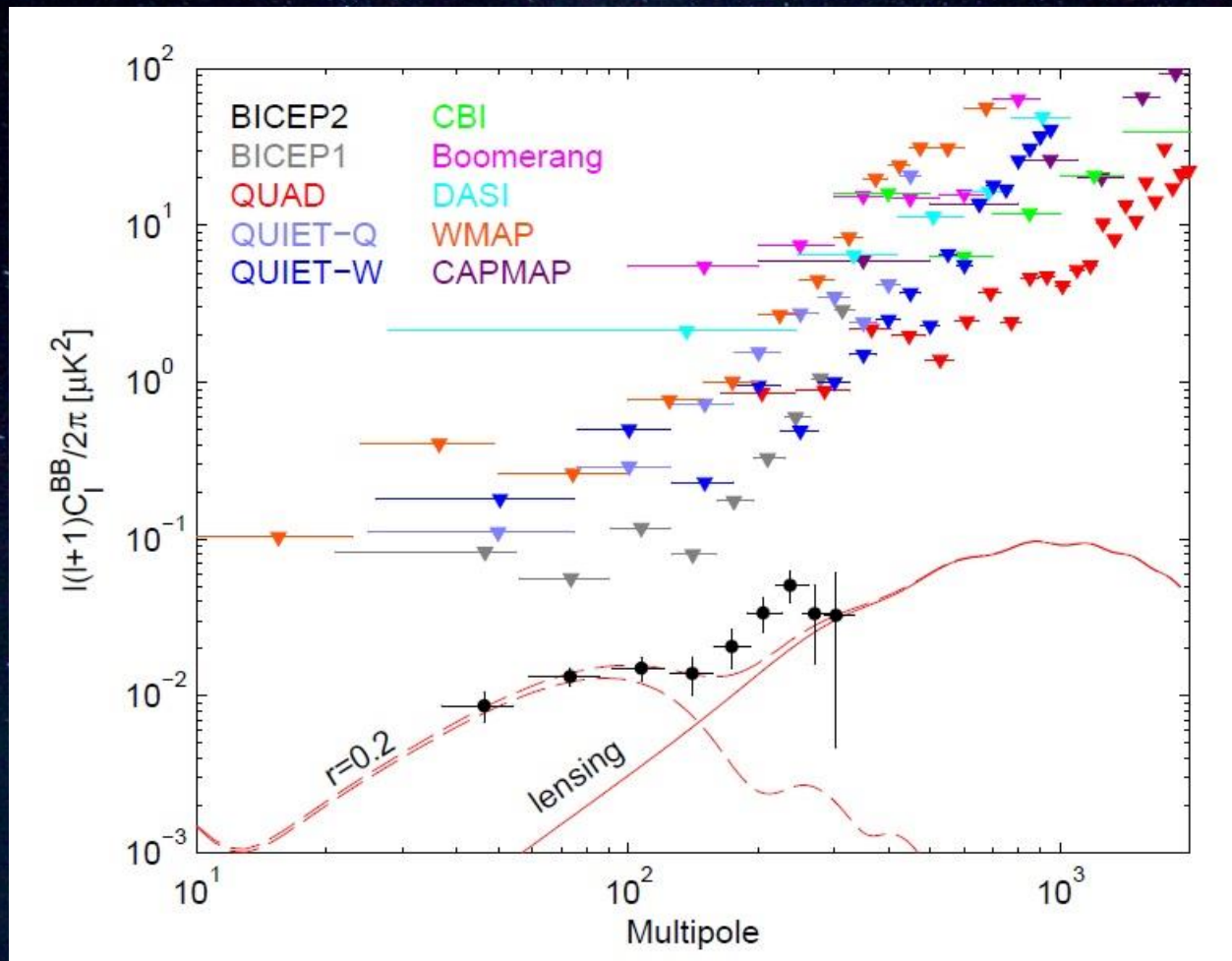






$$r \equiv \frac{\mathcal{P}_T}{\mathcal{P}_R}$$

$$r = 0.20^{+0.07}_{-0.05}$$



BICEP2 I: DETECTION OF B-mode POLARIZATION AT DEGREE ANGULAR SCALES

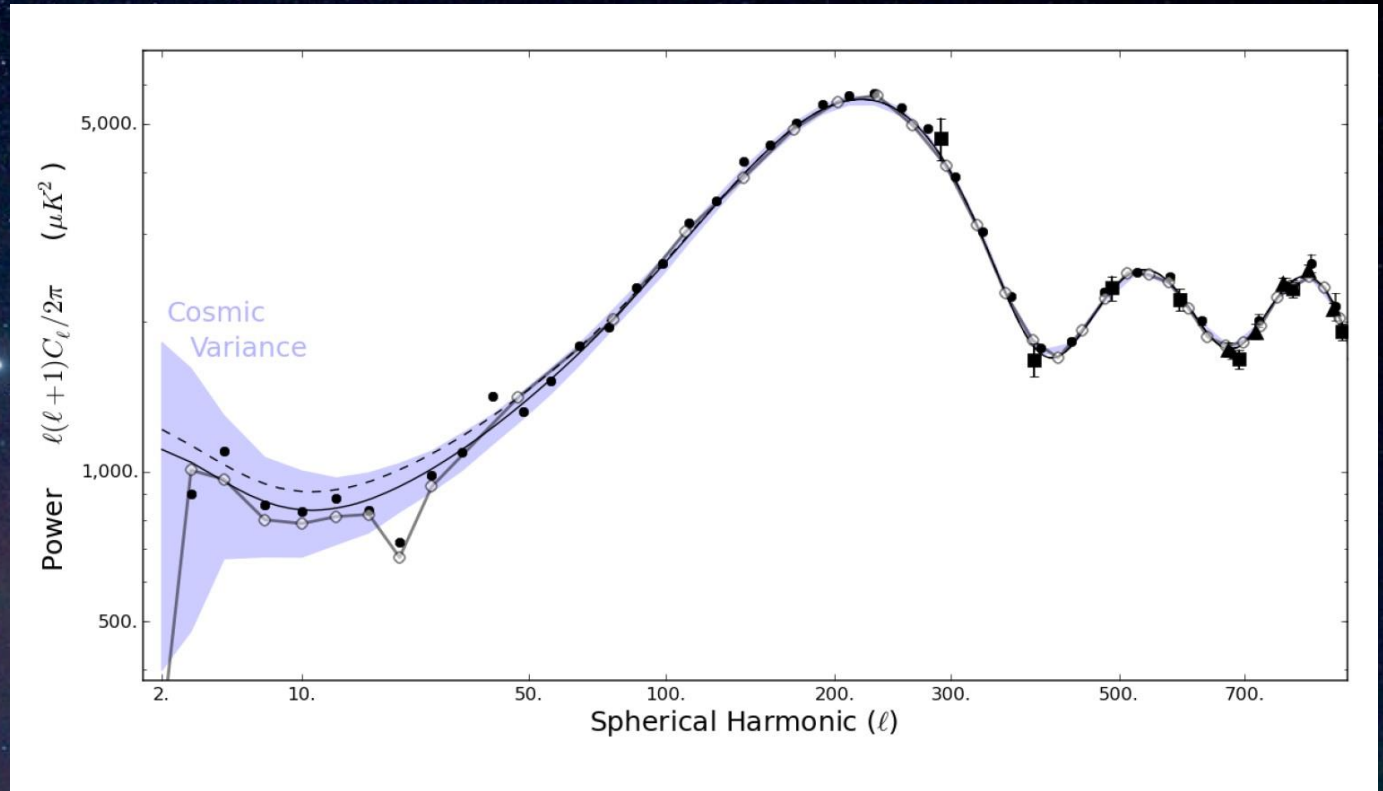
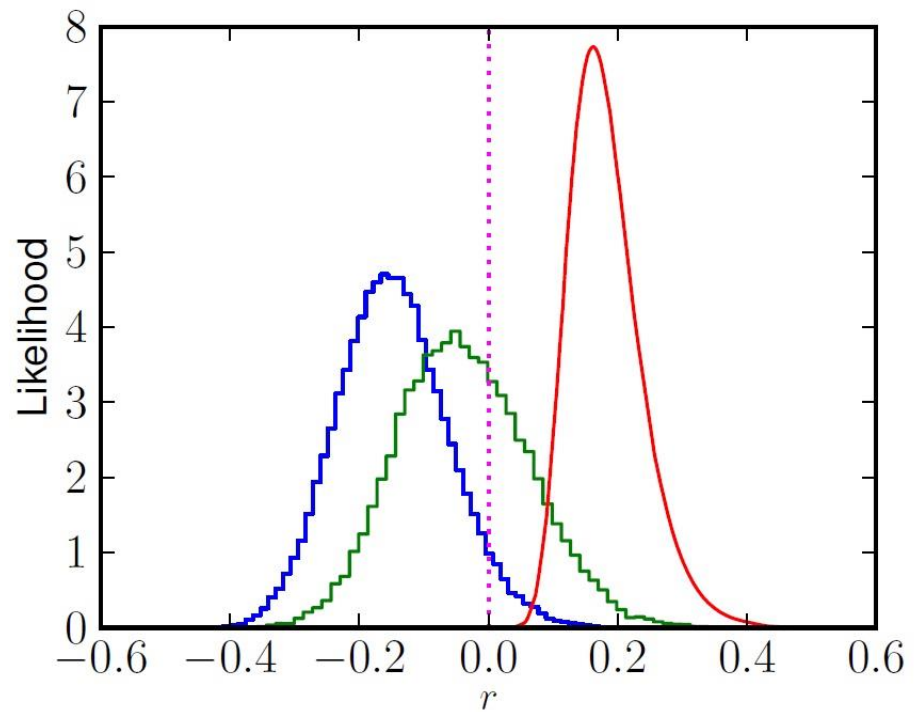
$$P_T(k) \equiv r P_S(k) = \frac{2H(k)^2}{\pi^2 M_{Pl}^2}$$

$$M_{Pl} = \sqrt{\hbar c / 8\pi G} = 2.435 \times 10^{18} \text{ GeV} / c^2$$



$$H(k_*) \approx 10^{14} \text{ GeV}$$





Kendrick M. Smith et.al



تصویر طفولیت کیهان

علی اکبر ابوالحسنی



پژوهشگاه دانش‌های بنیادی

- اندیس طیفی متغیر با مقیاس
- شکستگی در طیف توانی
- بستگی به مقیاس امواج گرانشی
- ناهمسانگردی امواج گرانشی

• ...

Planck Collaboration: Cosmological parameters

Planck Collaboration: Constraints on inflation

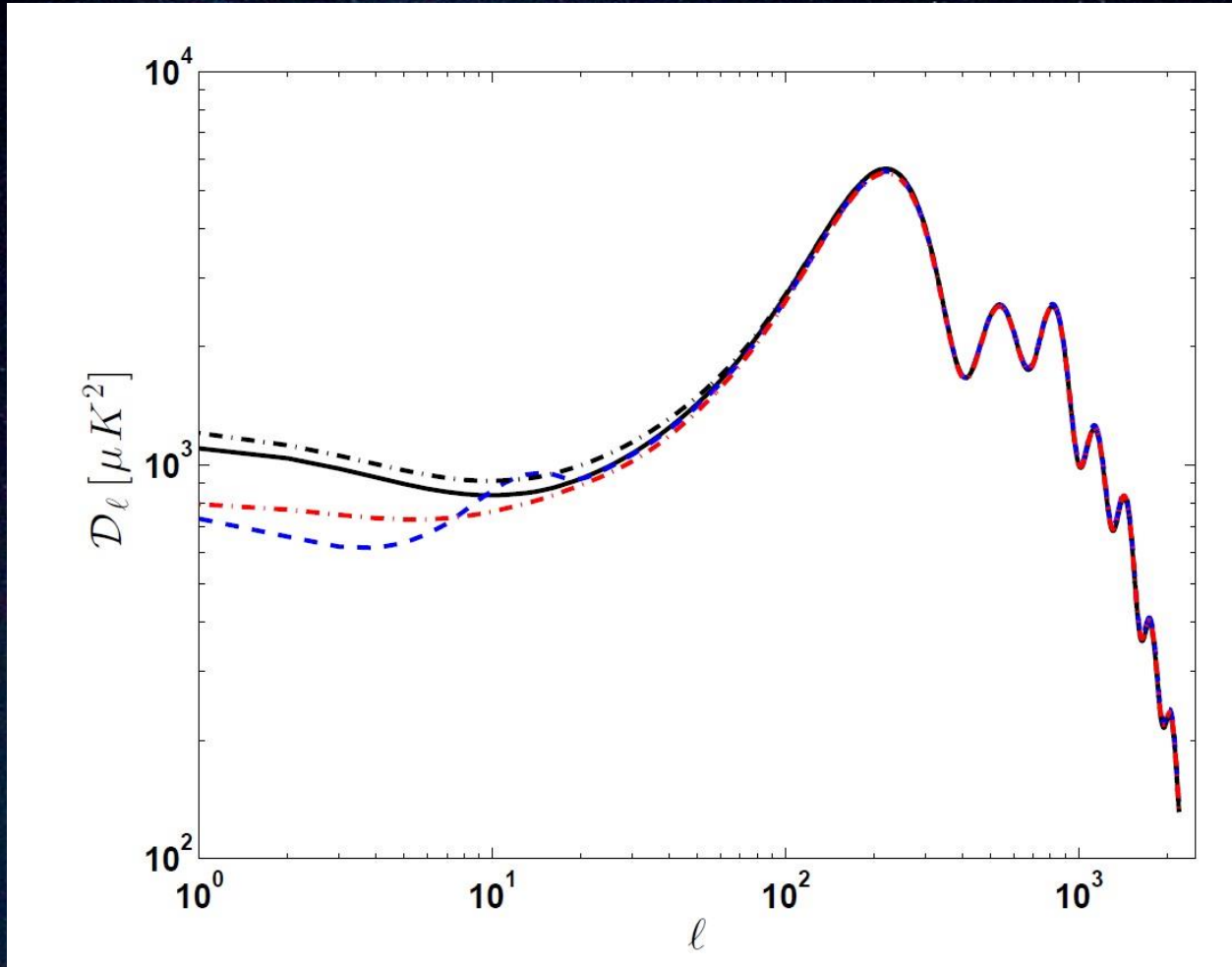
Model	Parameter	<i>Planck</i> +WP	<i>Planck</i> +WP+lensing	<i>Planck</i> +WP+high- ℓ	<i>Planck</i> +WP+BAO
Λ CDM + $dn_s/d \ln k$	n_s	0.9561 ± 0.0080	0.9615 ± 0.0072	0.9548 ± 0.0073	0.9596 ± 0.0063
	$dn_s/d \ln k$	-0.0134 ± 0.0090	-0.0094 ± 0.0085	-0.0149 ± 0.0085	-0.0130 ± 0.0090
	$-2\Delta \ln \mathcal{L}_{\max}$	-1.50	-0.77	-2.95	-1.45
Λ CDM + $dn_s/d \ln k$ + $d^2n_s/d \ln k^2$	n_s	$0.9514^{+0.087}_{-0.090}$	$0.9573^{+0.077}_{-0.079}$	$0.9476^{+0.086}_{-0.088}$	$0.9568^{+0.068}_{-0.063}$
	$dn_s/d \ln k$	$0.001^{+0.016}_{-0.014}$	$0.006^{+0.015}_{-0.014}$	$0.001^{+0.013}_{-0.014}$	$0.000^{+0.016}_{-0.013}$
	$d^2n_s/d \ln k^2$	$0.020^{+0.016}_{-0.015}$	$0.019^{+0.018}_{-0.014}$	$0.022^{+0.016}_{-0.013}$	$0.017^{+0.016}_{-0.014}$
	$-2\Delta \ln \mathcal{L}_{\max}$	-2.65	-2.14	-5.42	-2.40
Λ CDM + r + $dn_s/d \ln k$	n_s	0.9583 ± 0.0081	0.9633 ± 0.0072	0.9570 ± 0.0075	0.9607 ± 0.0063
	r	< 0.25	< 0.26	< 0.23	< 0.25
	$dn_s/d \ln k$	-0.021 ± 0.012	-0.017 ± 0.012	-0.022	
	$-2\Delta \ln \mathcal{L}_{\max}$	-1.53	-0.26	-3.2	

Free Photoshop PSD file download - resolution: 528x1024 px - www.psdgraphics.com



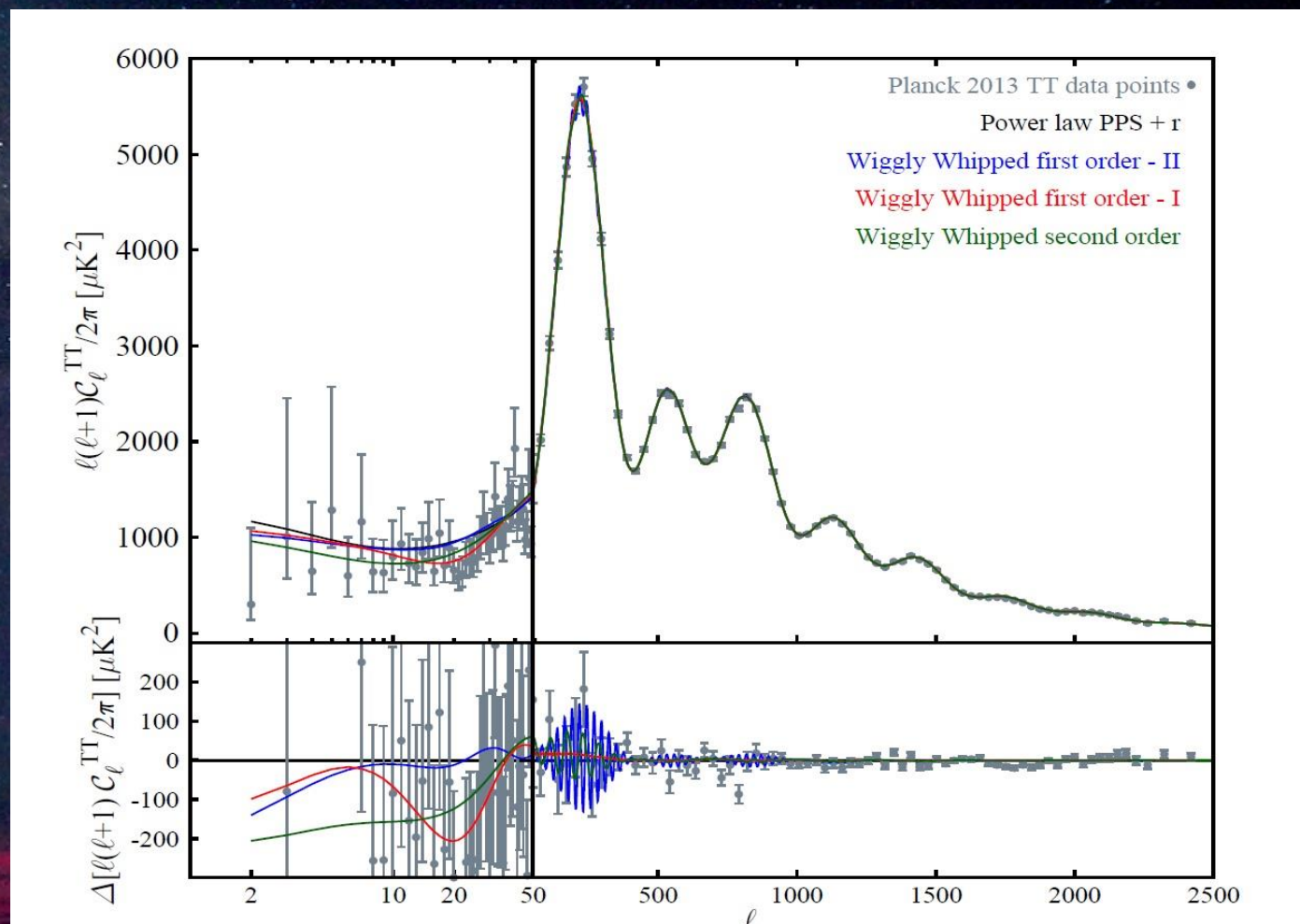
Planck Collaboration: Cosmological parameters

در تضاد با مدل های تورمی غلتش آرام

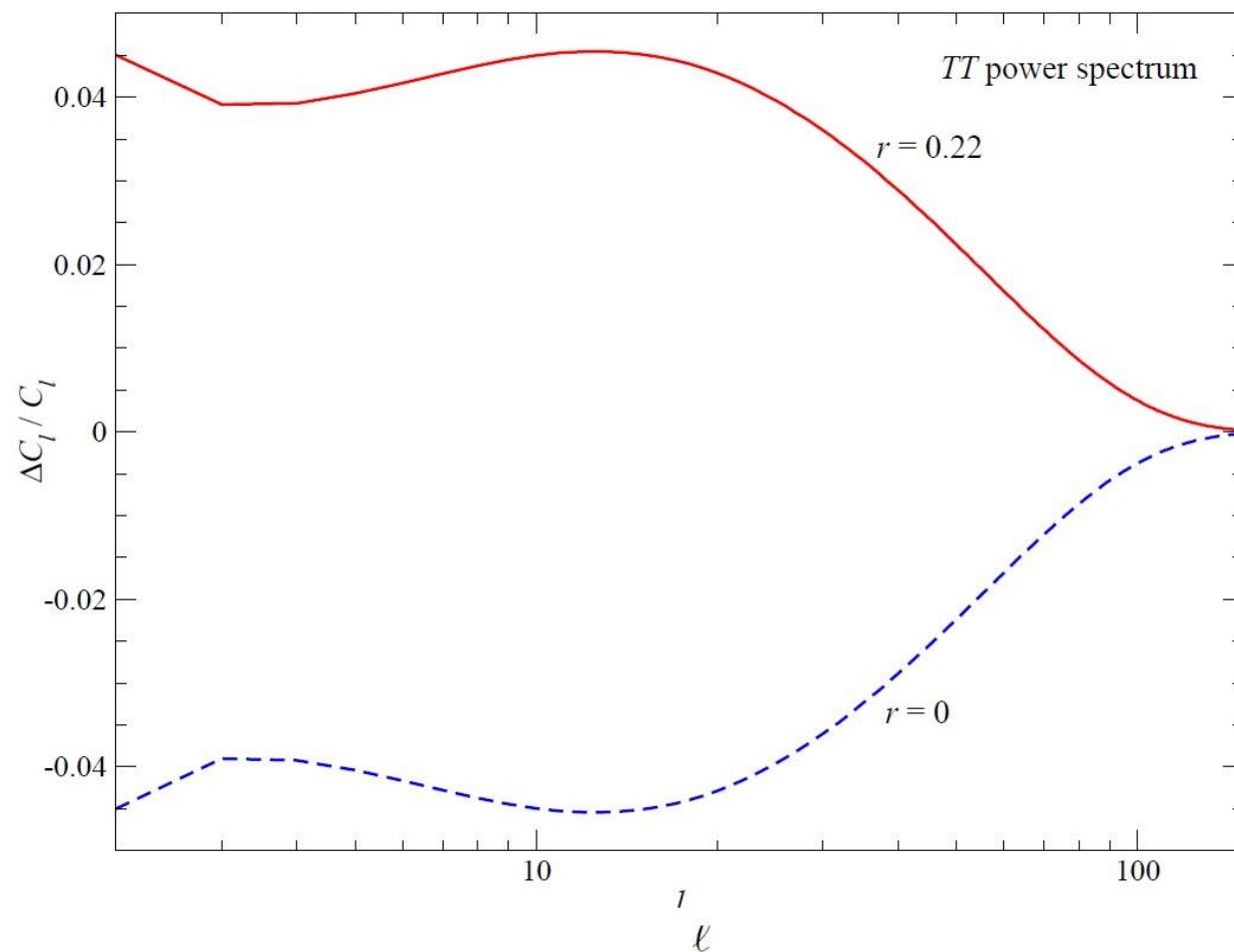


H. Firouzjahi and M. H. Namjoo

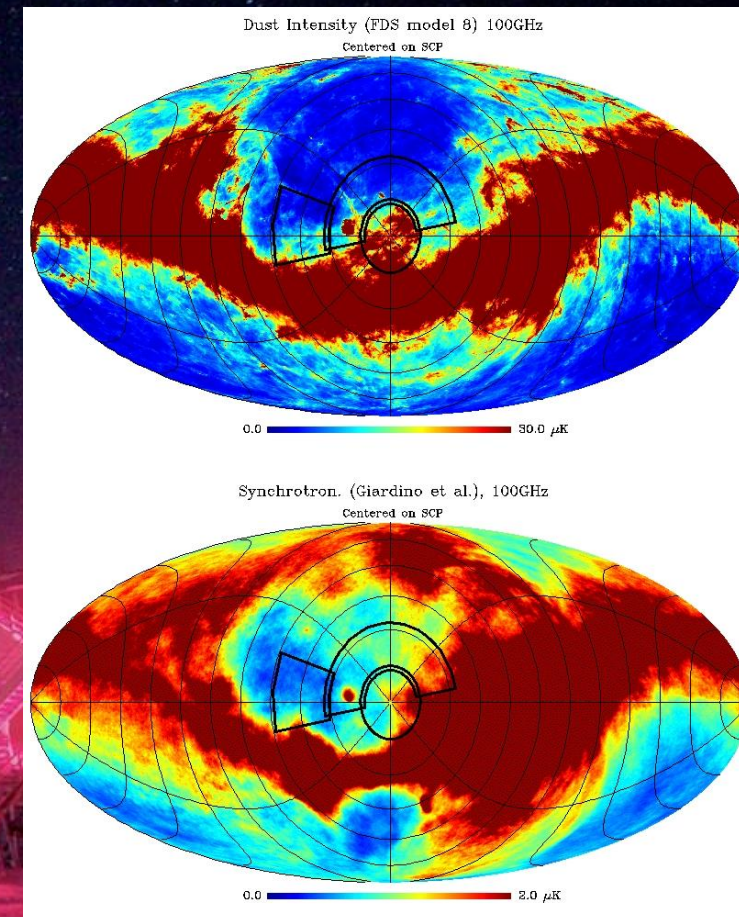
$$V(\phi) = \gamma\phi^p + \lambda\phi^p (\phi - \phi_0) \Theta(\phi - \phi_0),$$



عدم تقارن در دامنه اختلالات تانسوری



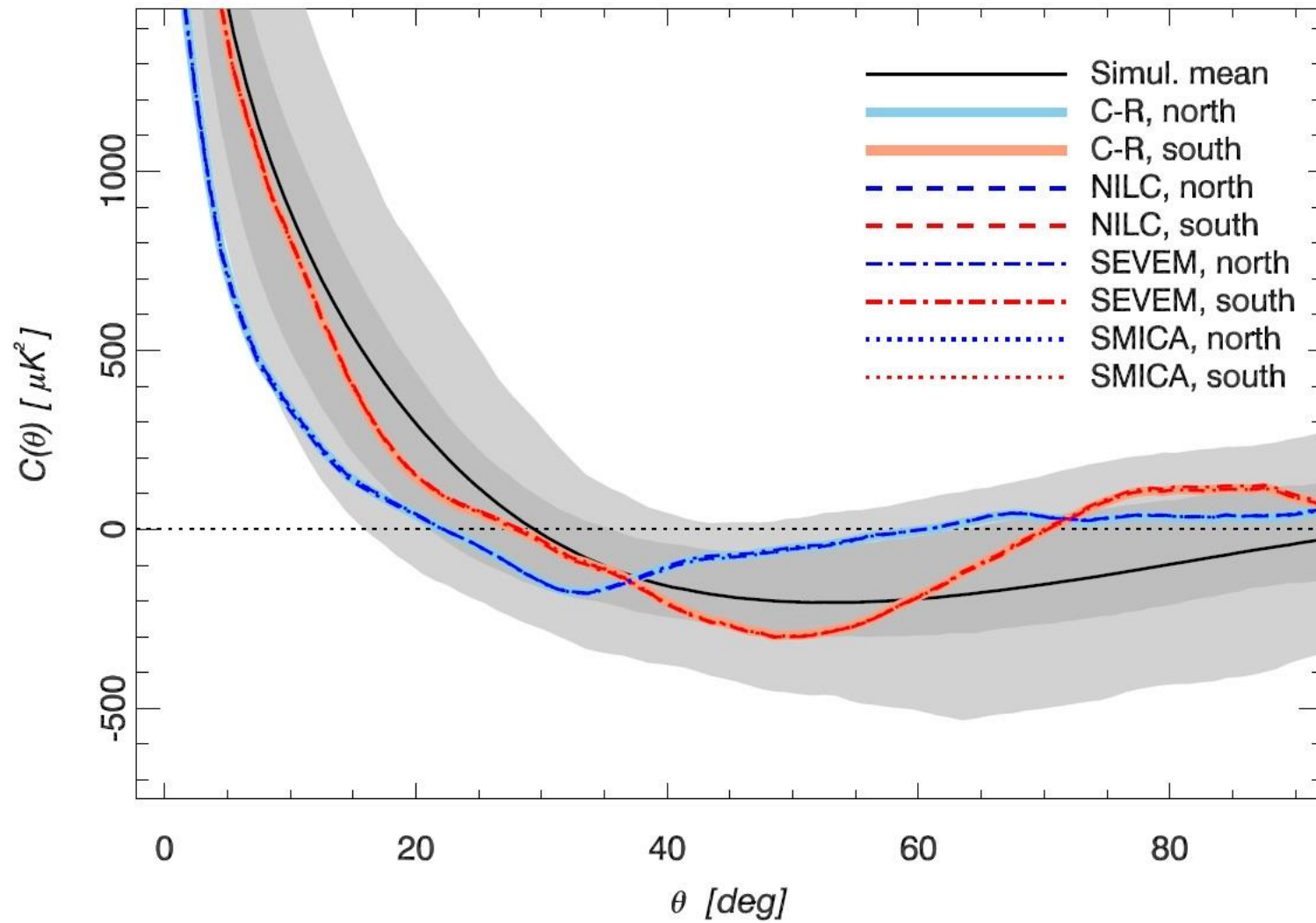
J. Chluba¹, L. Dai¹, D. Jeong, M. Kamionkowski¹ and A. Yoho



تصویر طفولیت کیهان

علی اکبر ابوالحسنی

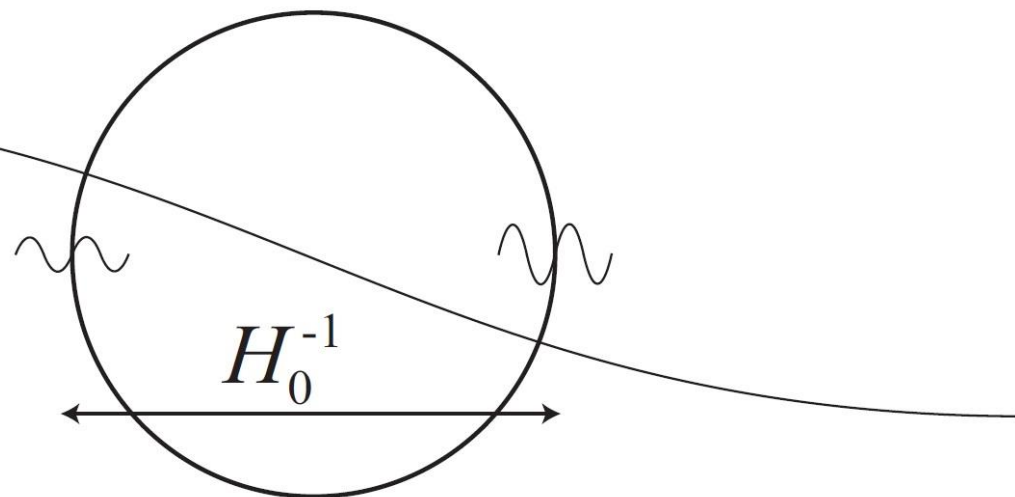
عدم تقارن کروی



Planck Collaboration: Isotropy and Statistics

تصویر طفولیت کیهان

علی اکبر ابوالحسنی



$$\frac{A_T}{A_{\mathcal{R}}} \simeq \frac{f_{NL}^{\mathcal{R}h}}{f_{NL}^{loc}}.$$

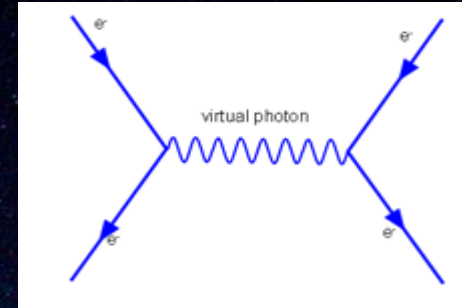
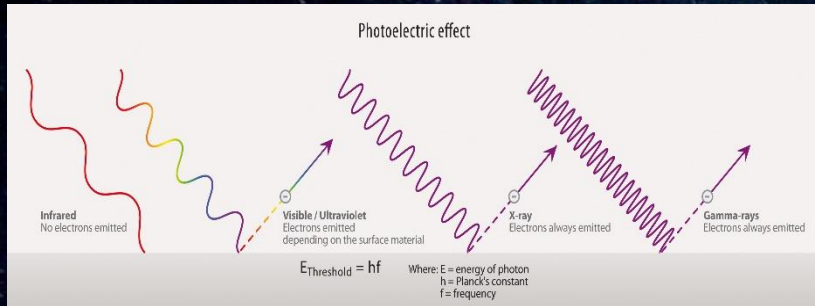
$$ds_{(3)}^2 = a(t)^2 e^{2\mathcal{R}(t,\mathbf{x})} {}^{(3)}g_{ij} d\mathbf{x}^i d\mathbf{x}^j$$

AAA, S. Baghran, H. Firouzjahi and M. H. Namjoo



تصویر طفولیت کیهان

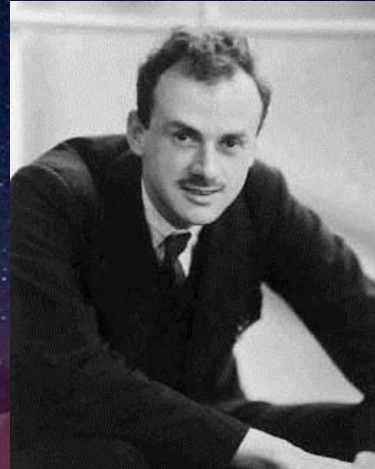
علی اکبر ابوالحسنی



1887



1905



1920



1947



1965

In 1887, Heinrich Hertz discovered that electrodes illuminated with ultraviolet light create electric sparks more easily. In 1905 Albert Einstein published a paper that explained experimental data from the photoelectric effect as being the result of light energy being carried in discrete quantized packets. This discovery led to the quantum revolution. Einstein was awarded the Nobel Prize in 1921 for "his discovery of the law of the photoelectric effect"

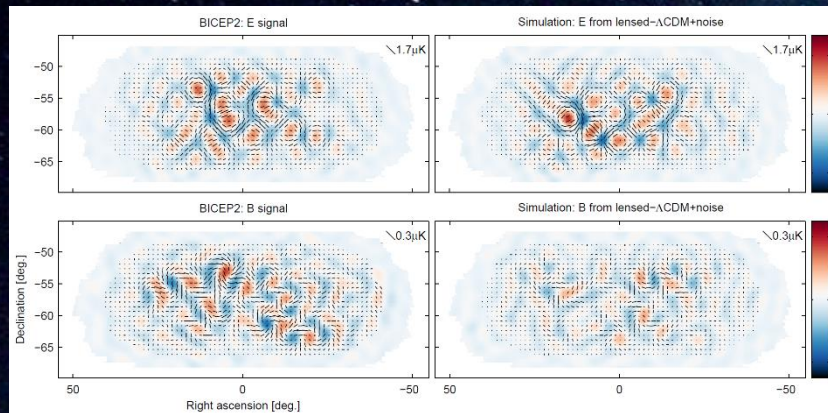
Based on Bethe's intuition and fundamental papers on the subject by Sin-Itiro Tomonaga, Julian Schwinger, Richard Feynman, and Freeman Dyson, it was finally possible to get fully covariant formulations that were finite at any order in a perturbation series of quantum electrodynamics. Sin-Itiro Tomonaga, Julian Schwinger, and Richard Feynman were jointly awarded with a Nobel prize in physics in 1965 for their work in this area.



تصویر طفولیت کیهان

علی اکبر ابوالحسنی

آیا در این مرحله هستیم؟



Quantum Gravity?



2014



????

تصویر طفولیت کیهان

علی اکبر ابوالحسنی

- کیفیت بی نظیر داده‌های مشاهداتی از منابع مختلف
- پیشرفت مدل‌های نظری
- توانایی کامپیوترهای جدید برای پردازش داده‌های رصدی برای مقایسه با پیش بینی‌های نظری

عصر طلایی کیهانشناسی