Данные миссии Planck и сравнение с WMAP: вопросы остаются ?

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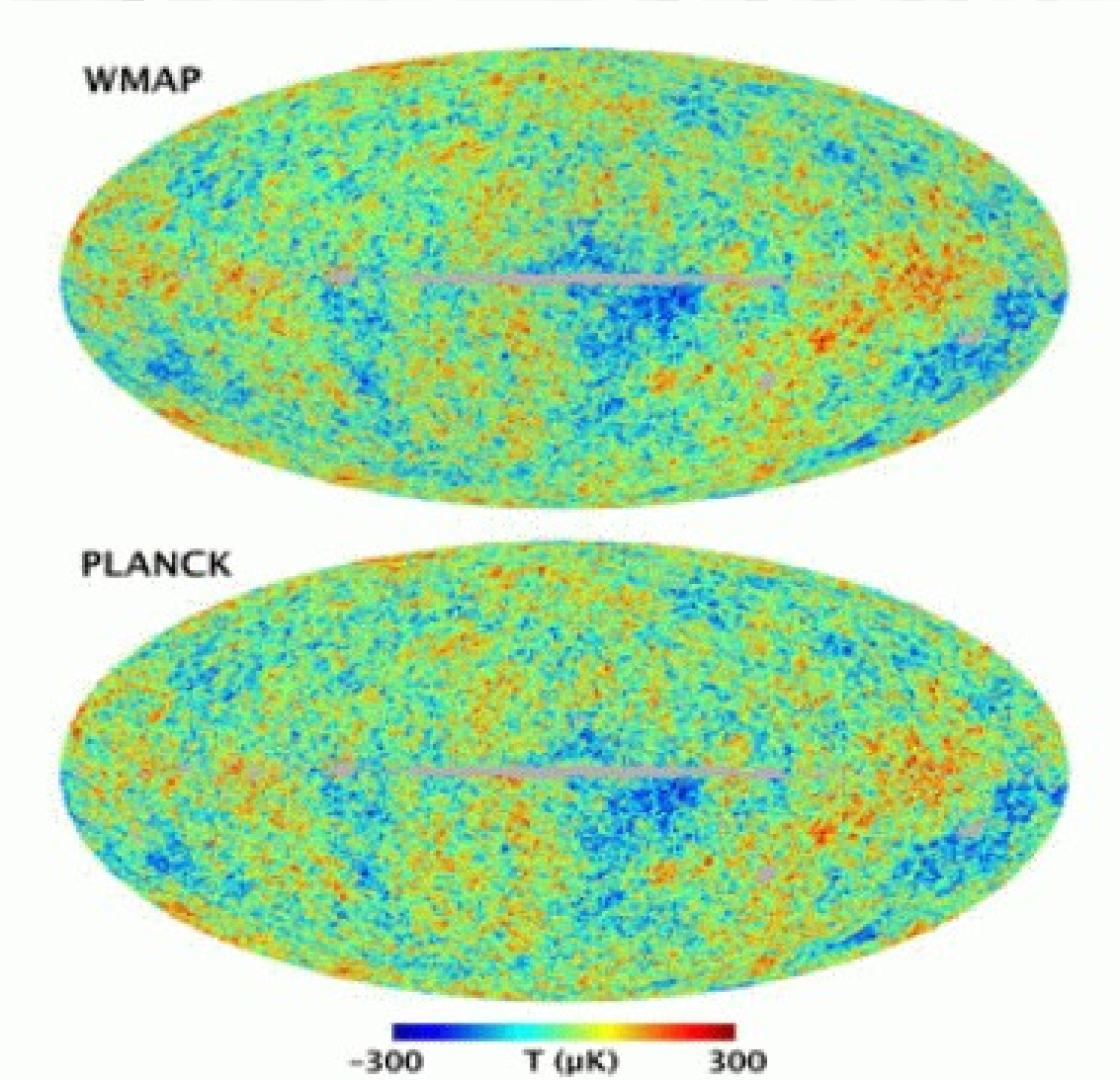
Legacy Planck Archive (LPA)

http://www.sciops.esa.int/index.php?page=Planck_Legacy_Archive&project=planck

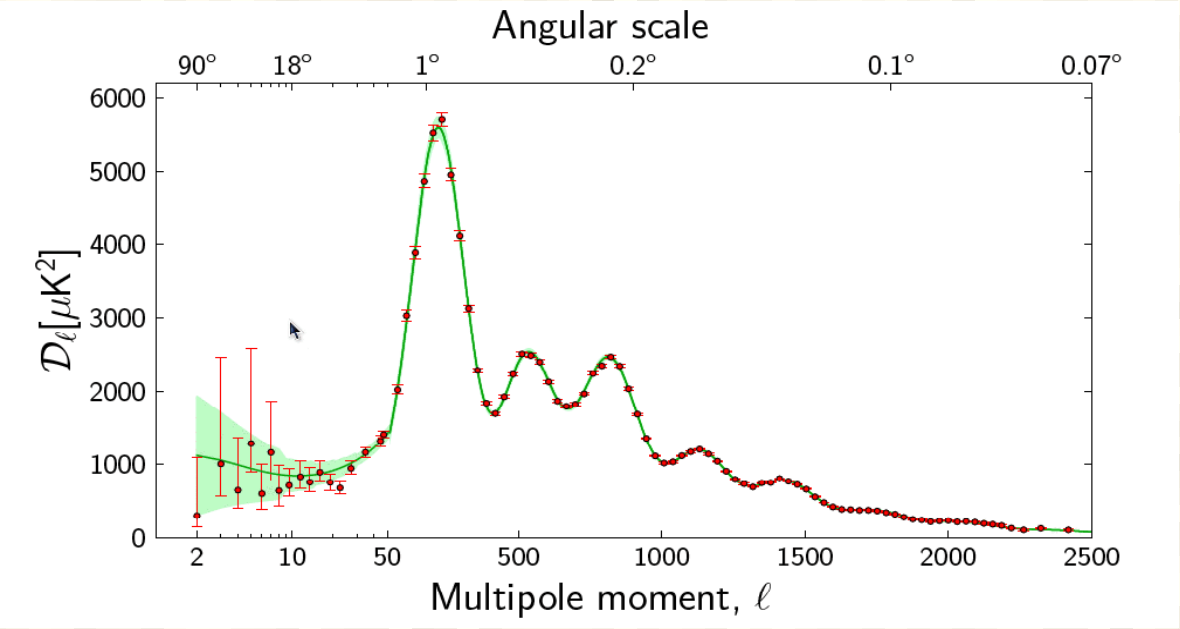
Maps:

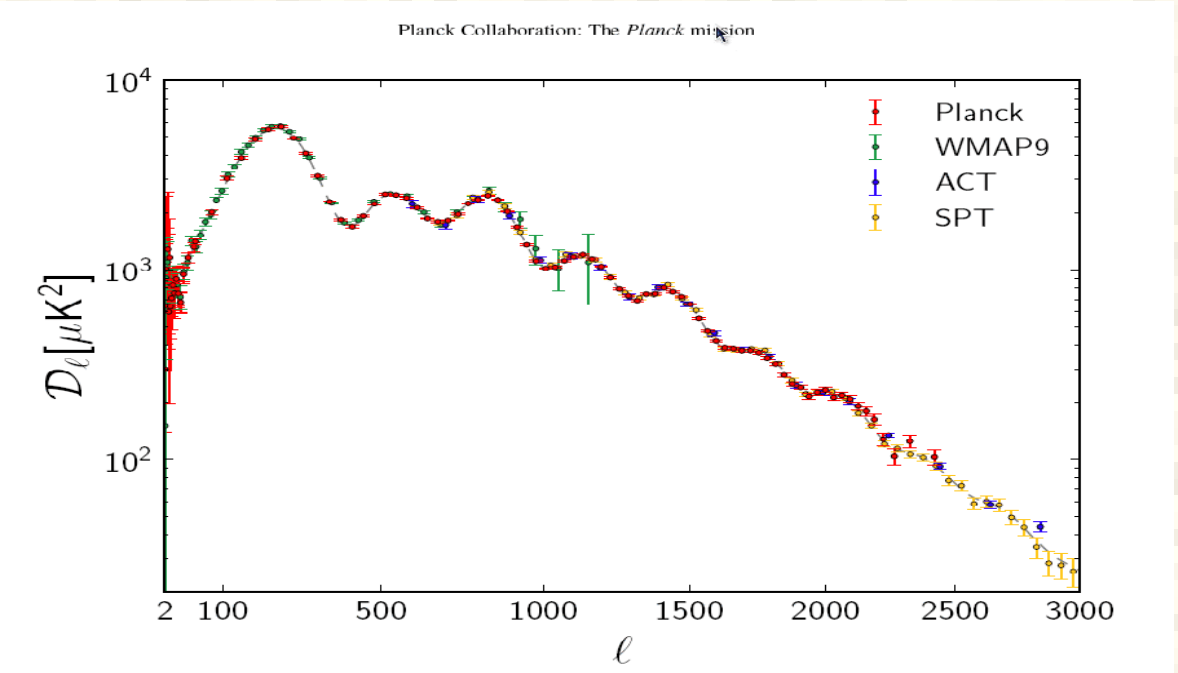
- SMICA +
- NILC +
- SEVEM +
- Commander-Ruler -

Карты WMAP9 и Planck



Спектры мощности





Космологические результаты WMAP9 и Planck

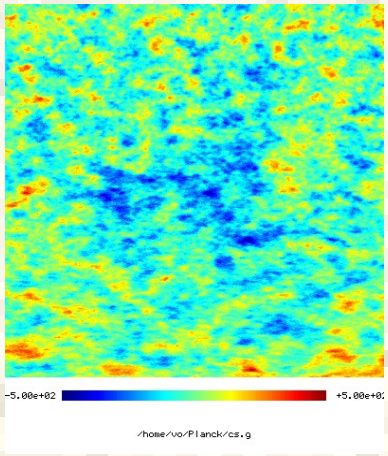
http://lambda.gsfc.nasa.gov

Comparison of *Planck*-only and *WMAP*-only Six-Parameter ΛCDM Fits[a]

Parameter	*Planck* ("CMB+Lens")	*WMAP* (9-year)	Difference value	Difference *WMAP* σ
$\Omega_b h^2$	0.02217 ± 0.00033	0.02264 ± 0.00050	-0.00047	0.9
$\Omega_c h^2$	0.1186 ± 0.0031	0.1138 ± 0.0045	0.0048	1.1
Ω_Λ	0.693 ± 0.019	0.721 ± 0.025	-0.028	1.1
τ	0.089 ± 0.032	0.089 ± 0.014	0	0
t_0 (Gyr)	13.796 ± 0.058	13.74 ± 0.11	56 Myr	0.5
H_0 (km s^{-1}Mpc^{-1})	67.9 ± 1.5	70.0 ± 2.2	-2.1	1.0
σ_8	0.823 ± 0.018	0.821 ± 0.023	0.002	0.1
Ω_b	0.0481[b]	0.0463 ± 0.0024	0.0018	0.7
Ω_c	0.257[b]	0.233 ± 0.023	0.024	1.0

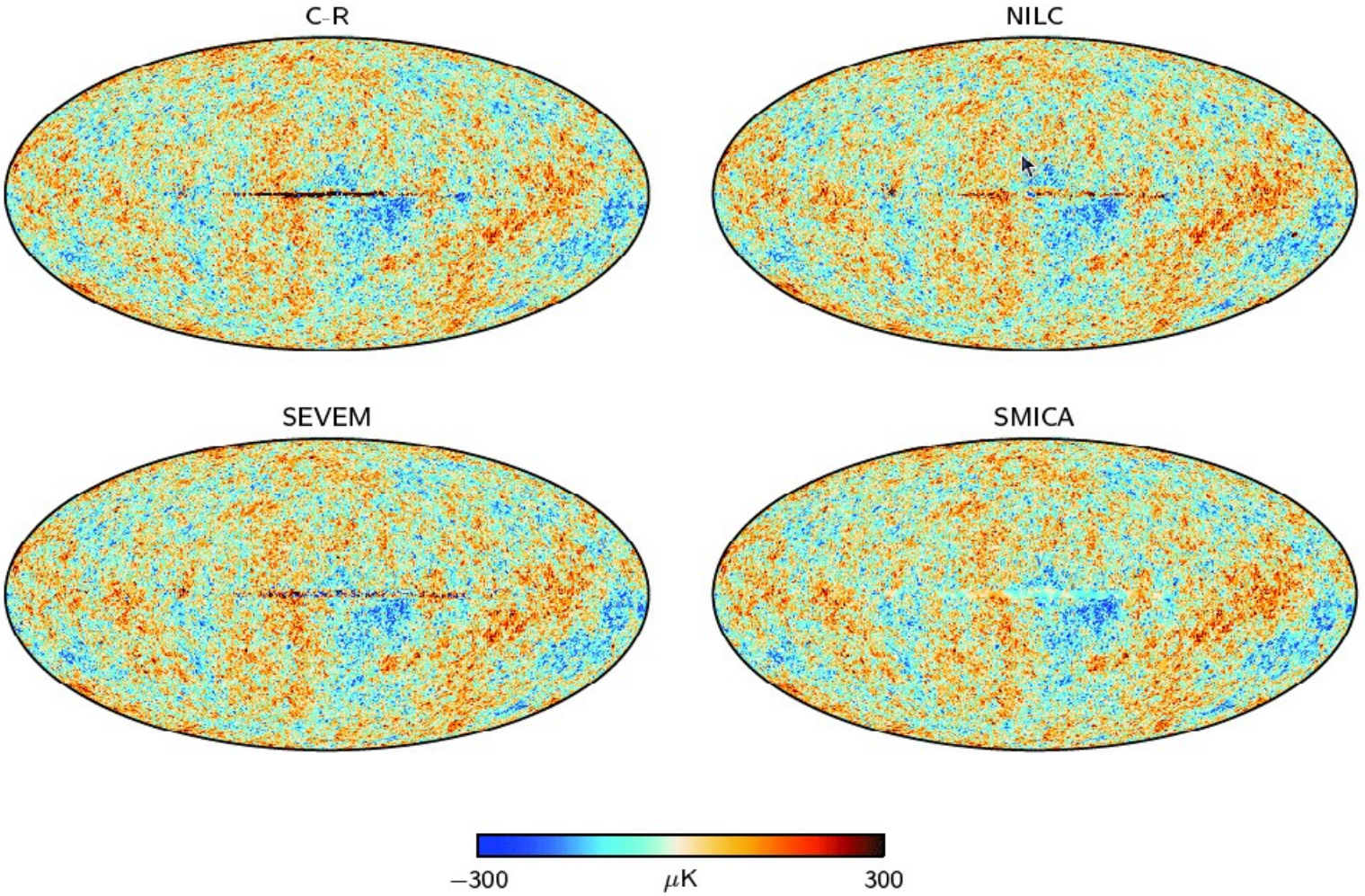
Революции нет...

Аномалии



1) Холодное Пятно — есть
2) Ось Зла — сказано: «нет»
3) Первичная негауссовость — предел очень низкий
4) Нарушение четности спектра — есть
5) Асимметрия Север — Юг в гал. и экл. системах — есть
6) Символов 'SH' — нет (Ура) ! - все-таки есть...

Карты

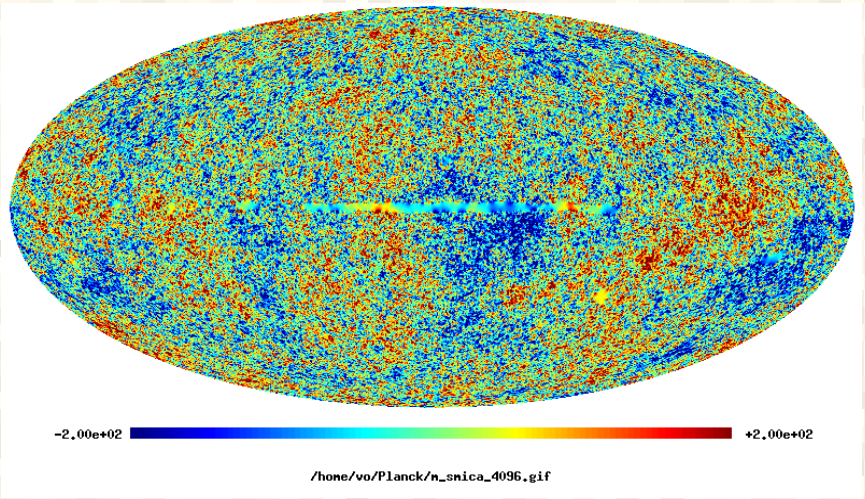

C–R
NILC
SEVEM
SMICA
−300
μK
300

Карты Planck: разделение компонент

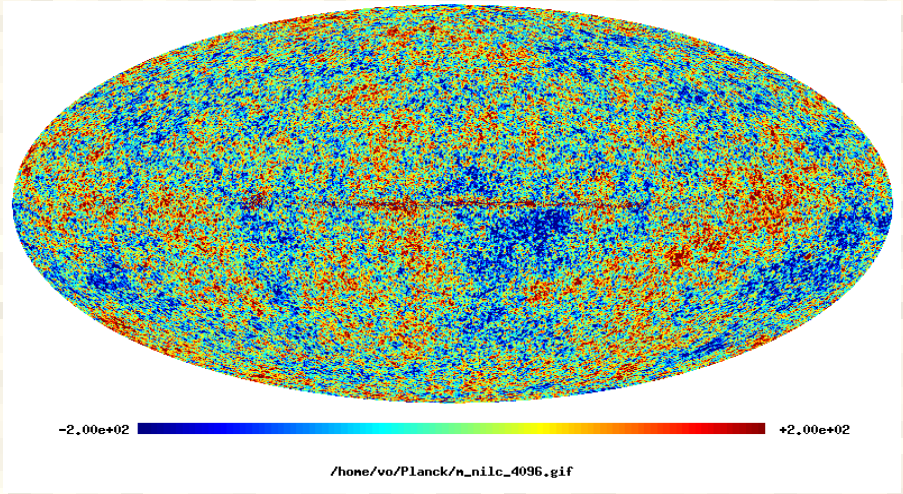
Table 1: Overview and comparison of component separation algorithms.

Characteristic	Commander-Ruler	NILC	SEVEM	SMICA
Method	Bayesian parameter estimation	Internal linear combination	Internal template fitting	Spectral parameter estimation
Domain	Pixel	Needlet	Pixel	Spherical harmonic
Channels [GHz]	30–353	44–857	30–857	30–857
Effective beam FWHM [arcmin]	~7.4	5.0	5.0	5.0
$\ell_{\rm max}$	none	3200	3100	4000

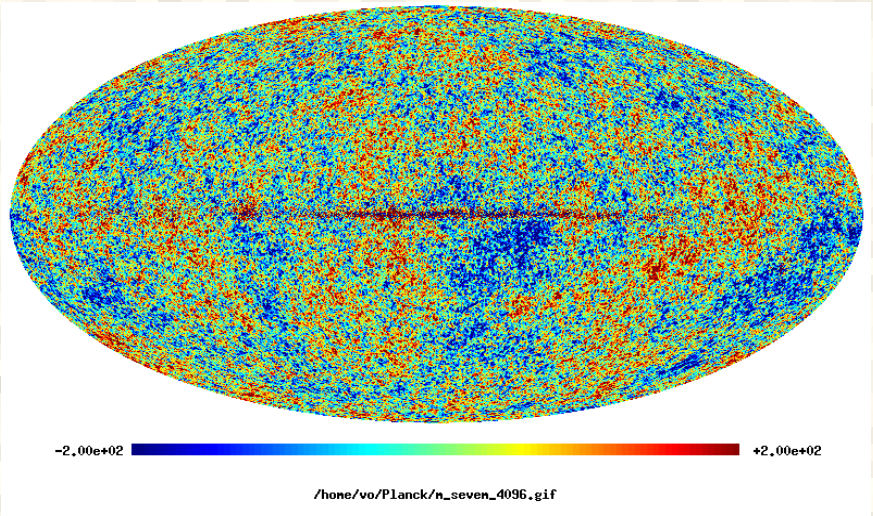
Карты



SMICA



NILC



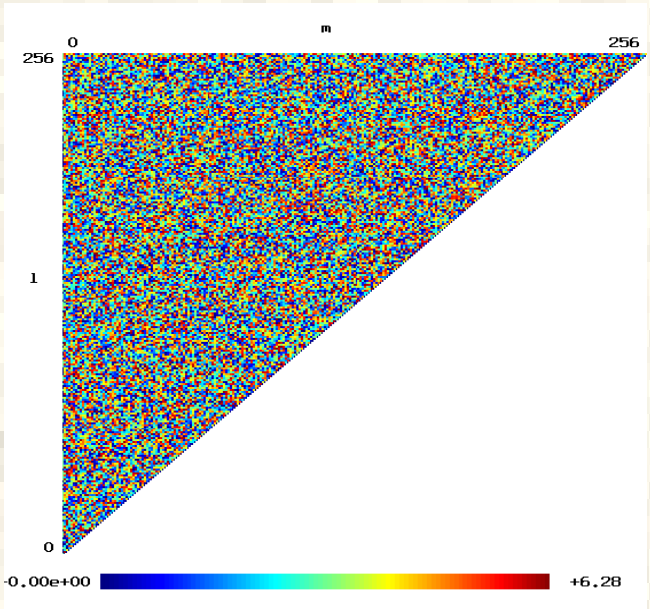
SEVEM

Фазы

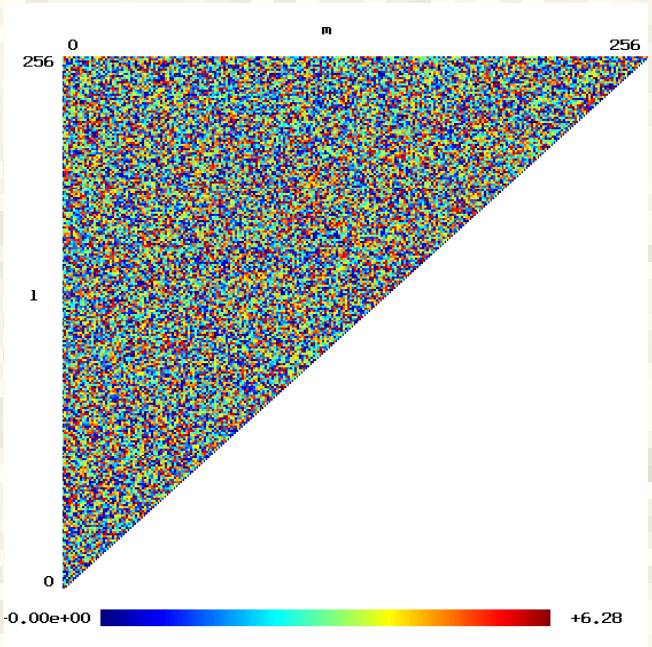
$$\Delta T(\theta,\phi) = \sum_{l=2}^{\infty} \sum_{m=-l}^{m=l} a_{l,m} Y_{l,m}(\theta,\phi)$$

$$a_{\ell m} = |a_{\ell m}| \exp(i\psi_{\ell m})$$

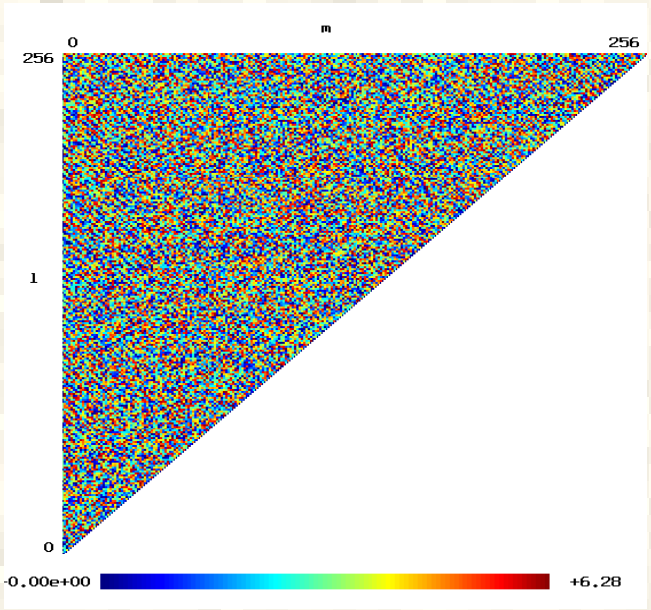
Фазы



SMICA

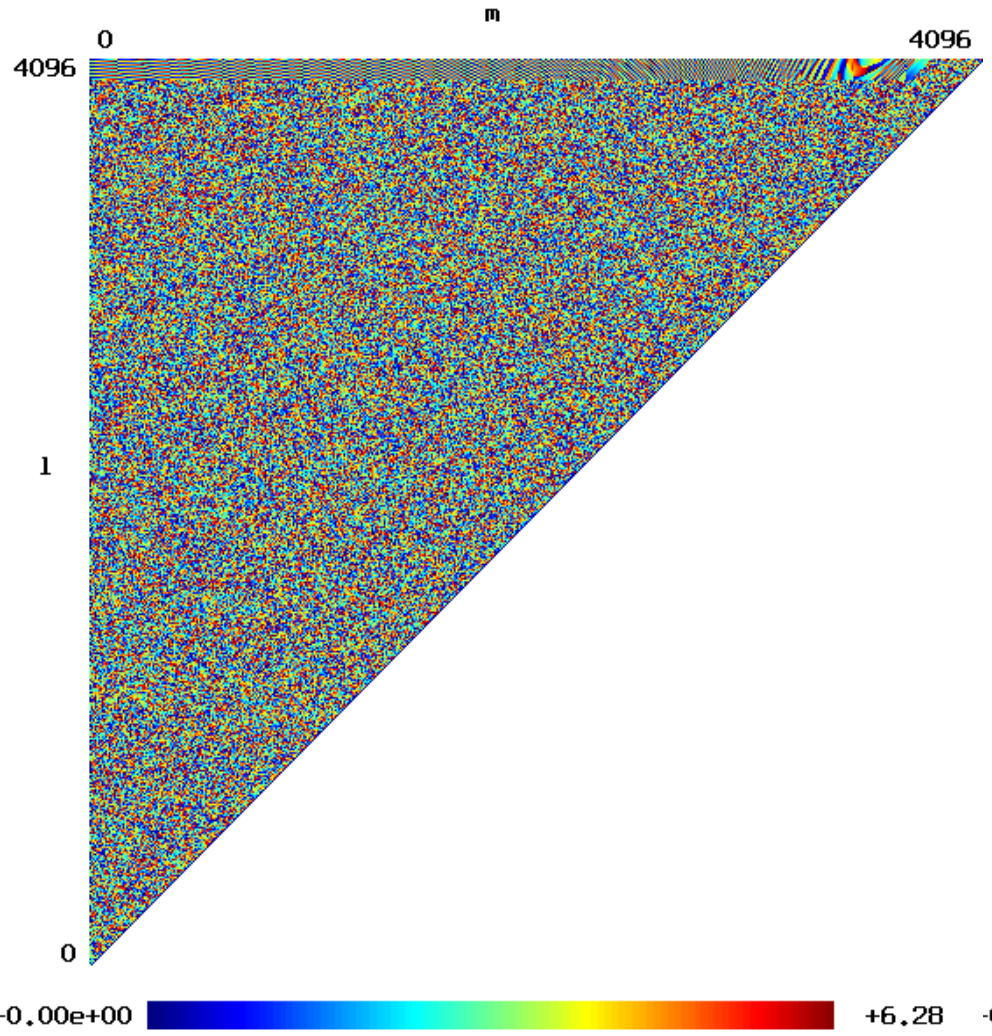


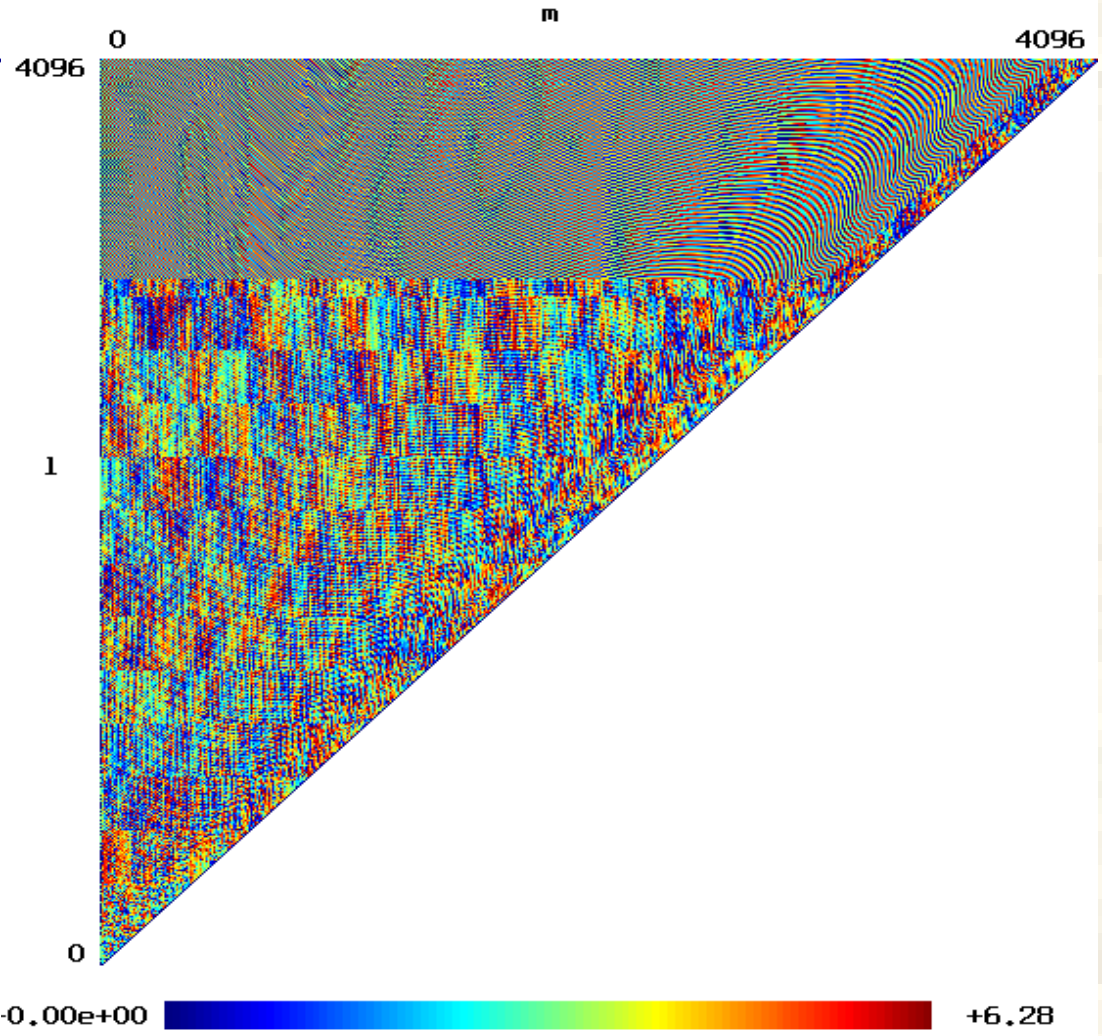
NILC



SEVEM

Фазы, L<=4096

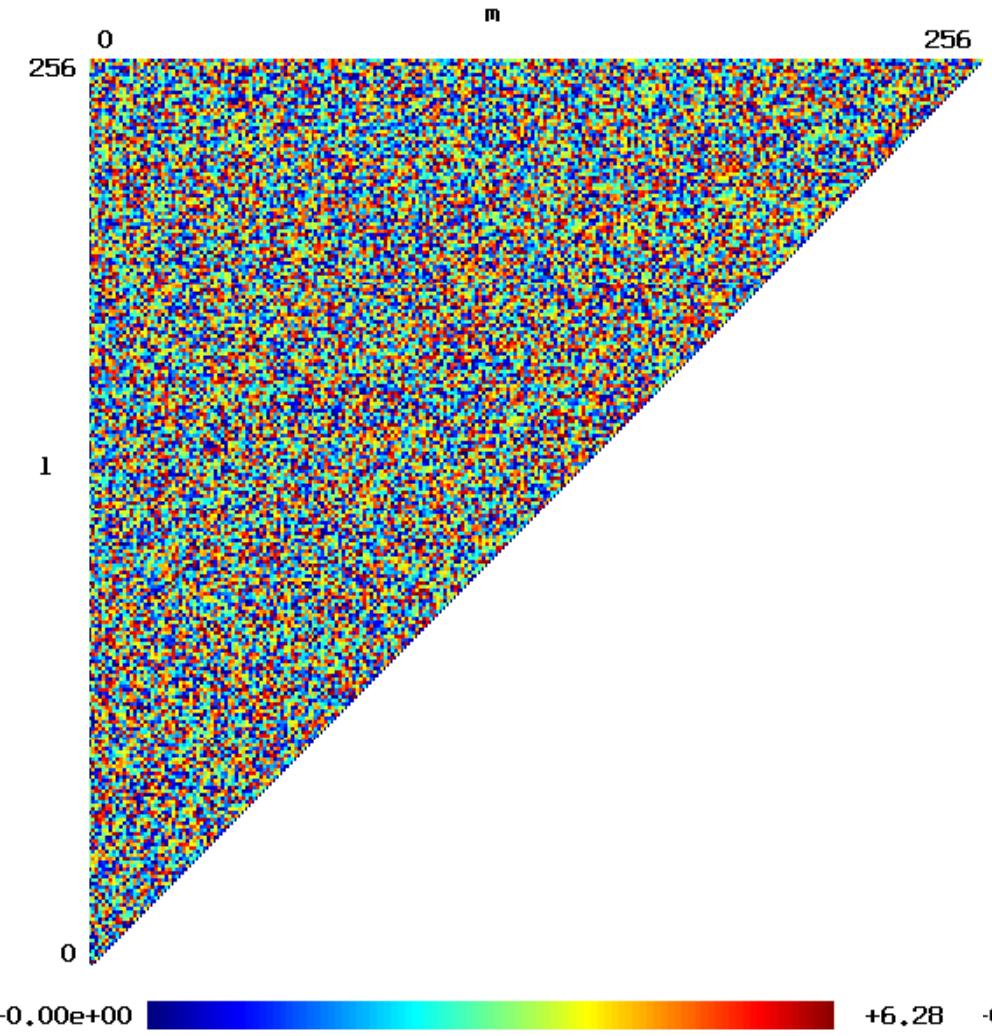


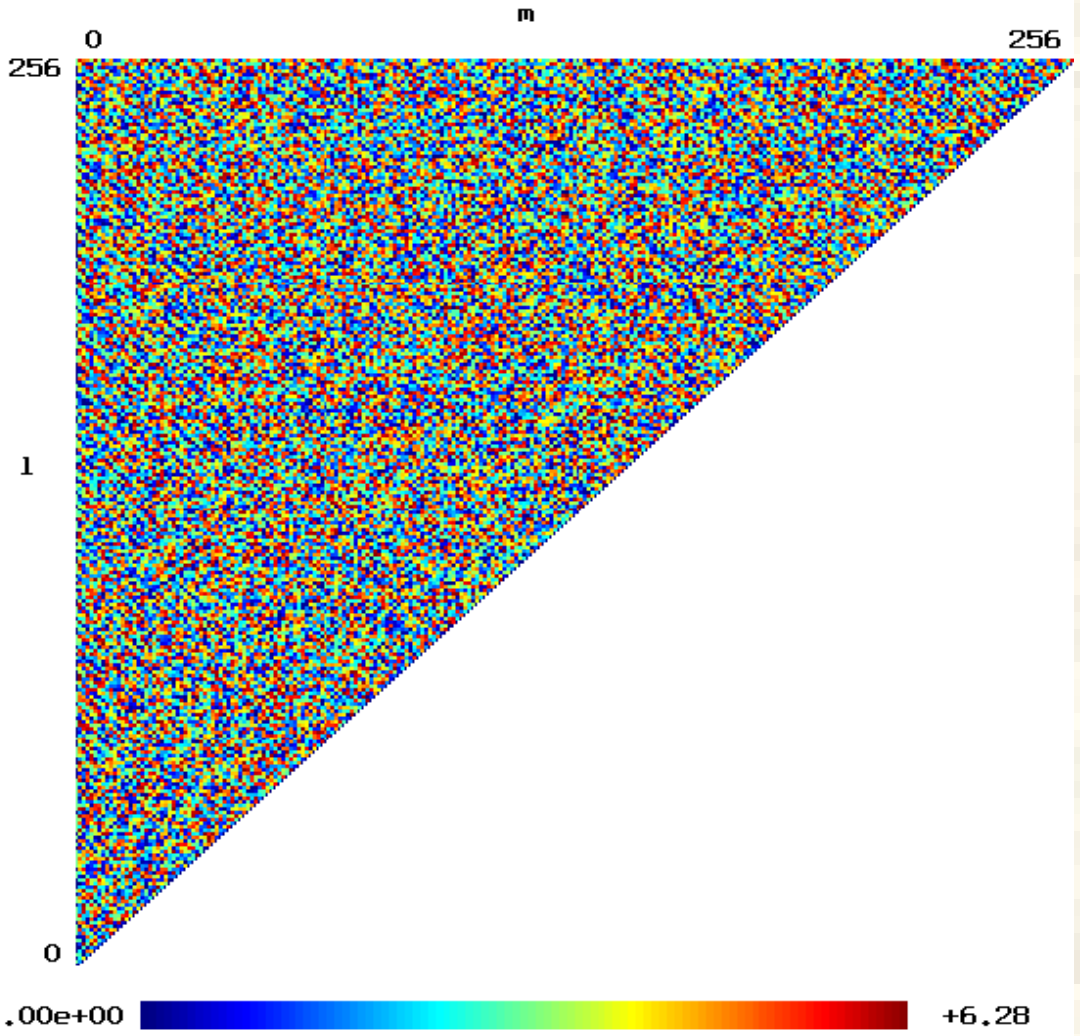


SMICA

SEVEM

Фазы, L<=256

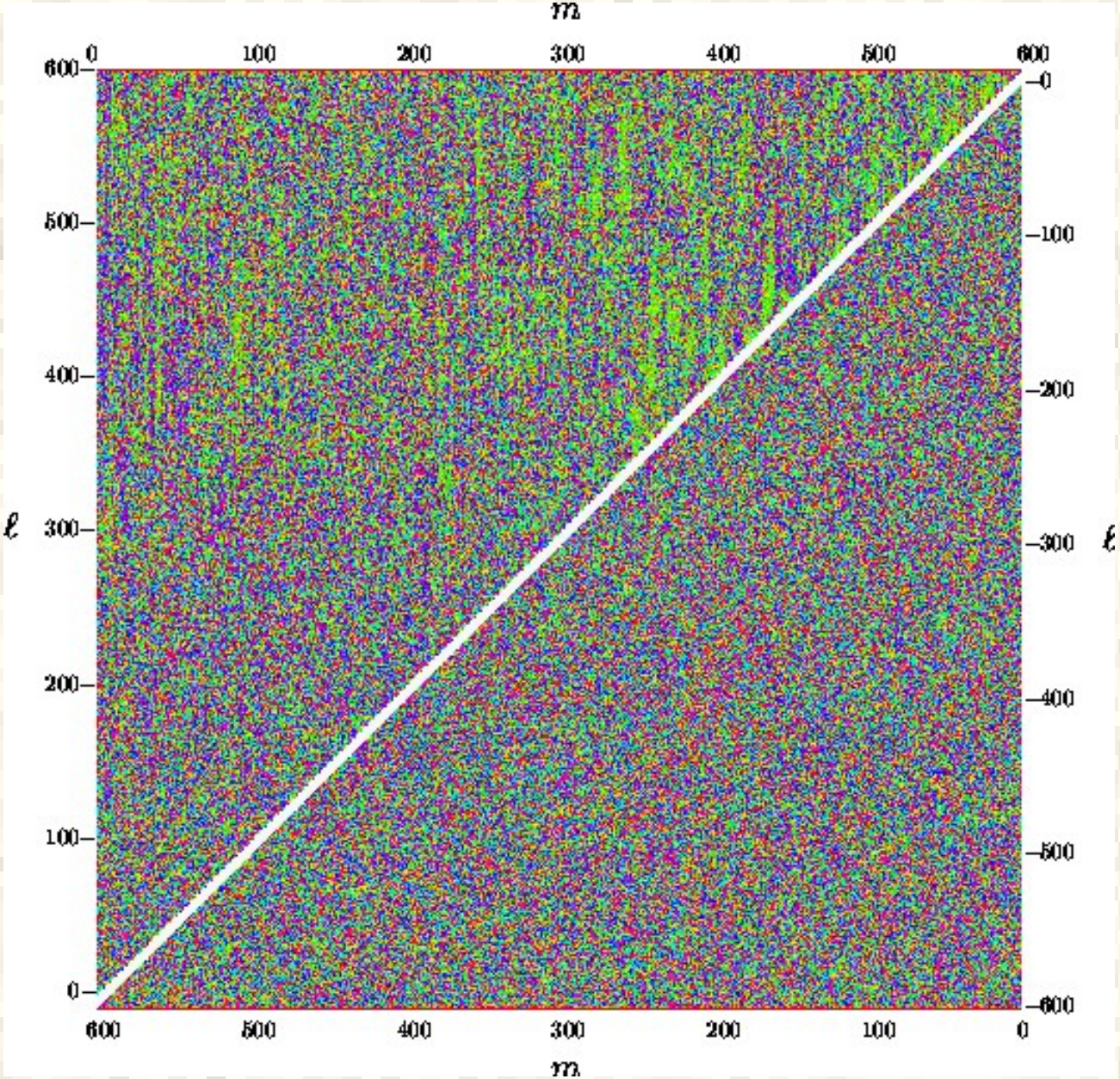




SMICA

SEVEM

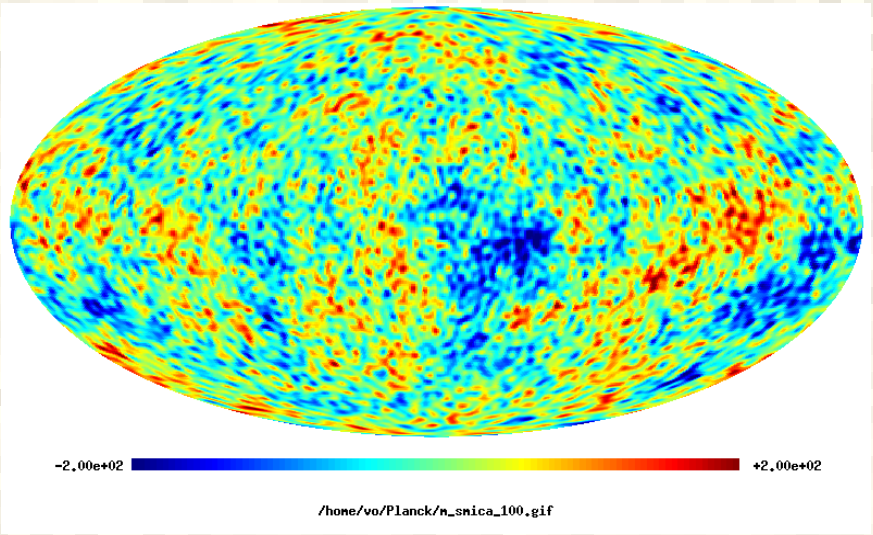
Чтобы не забыть...



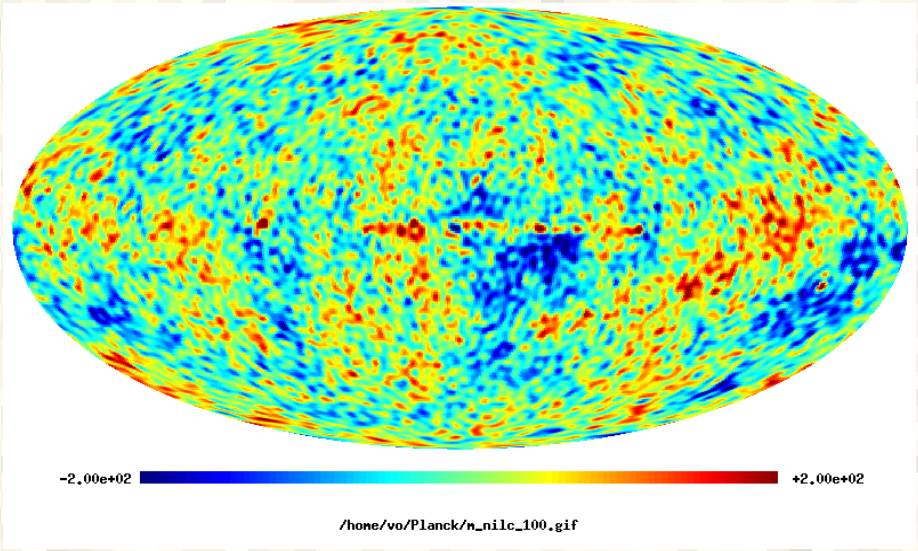
WMAP:
2 карты
Тегмарка

(Chiang et al. 2003)

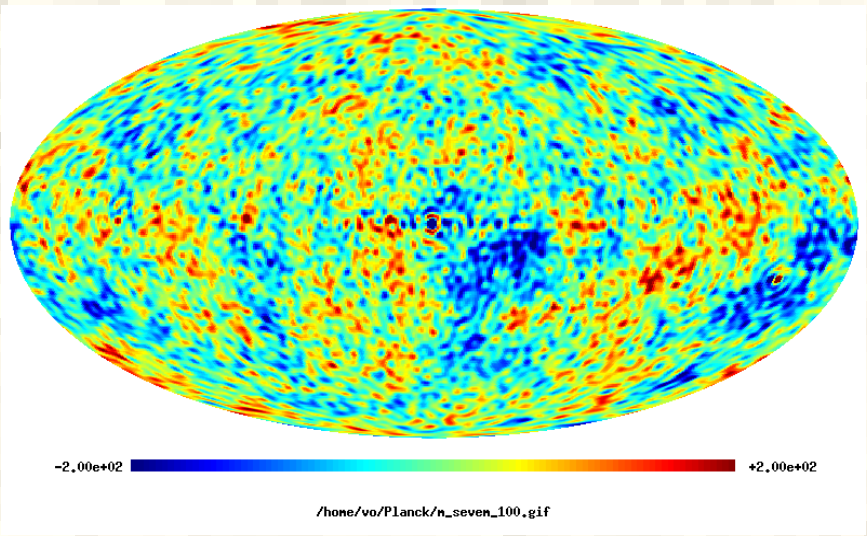
Карты, L<=100



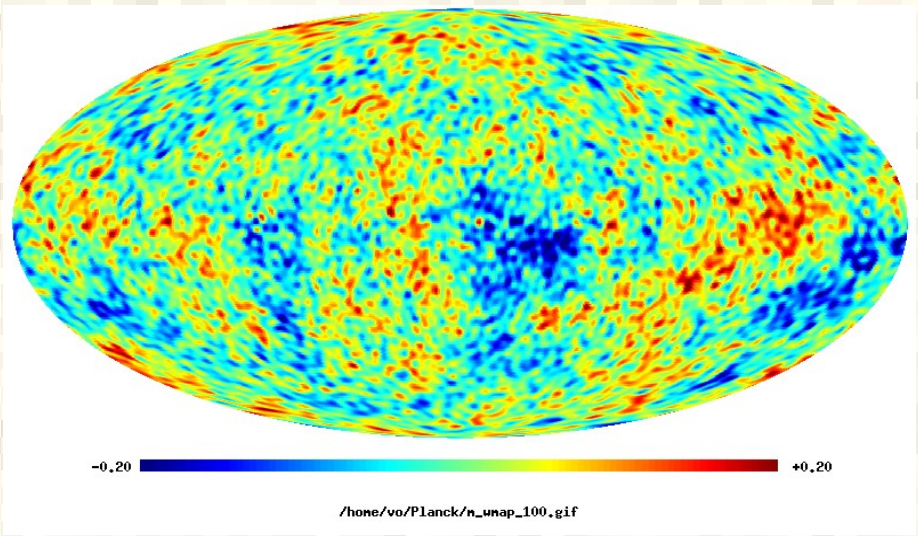
SMICA



NILC

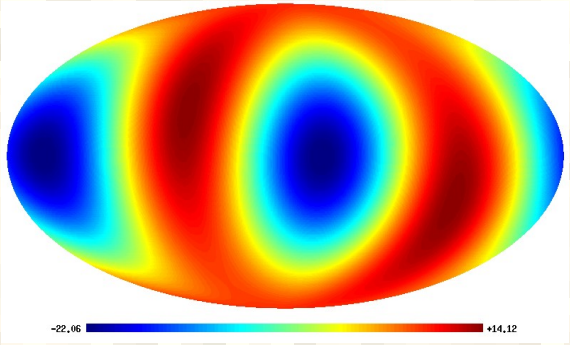


SEVEM



WMAP9

Низкие мультиполи в Planck-е



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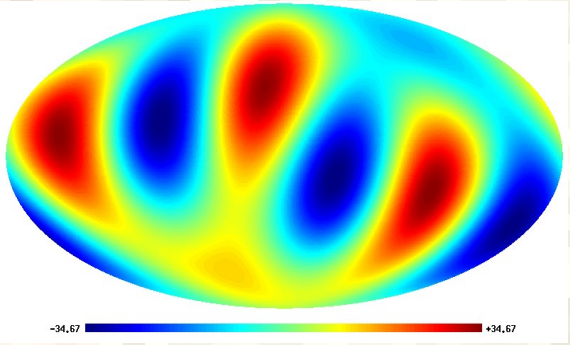

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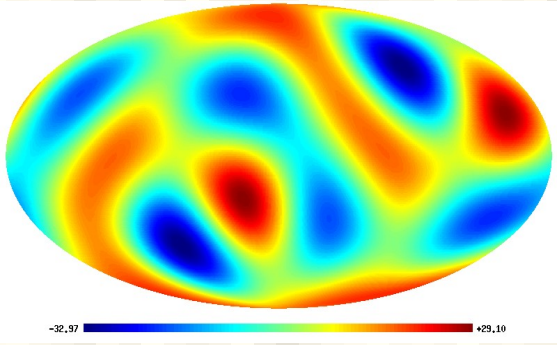

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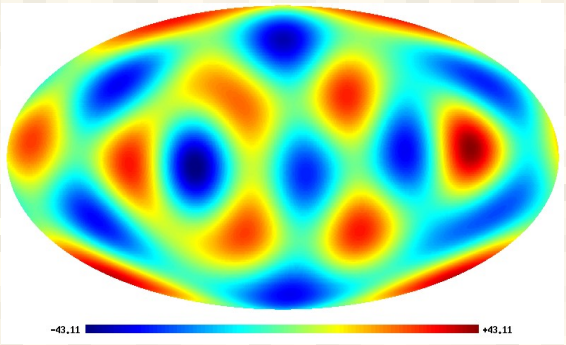

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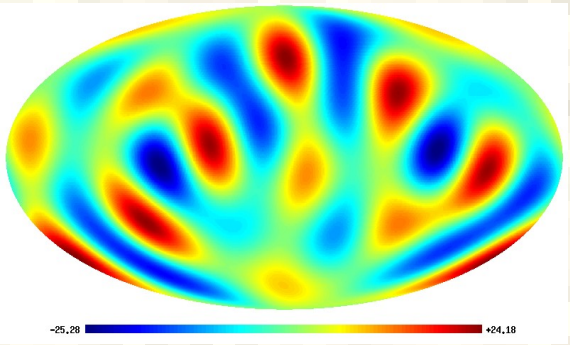

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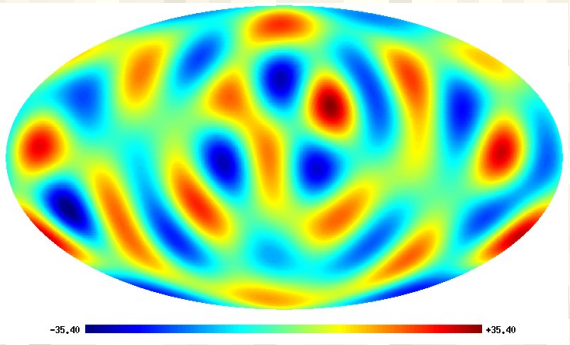

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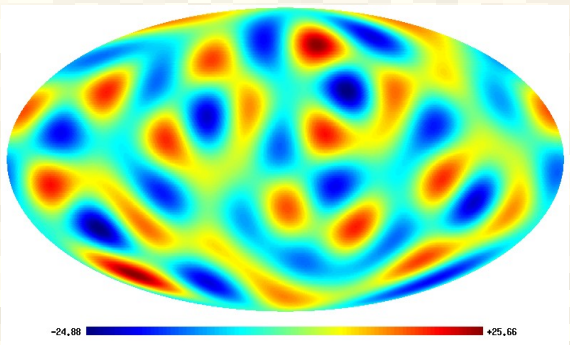

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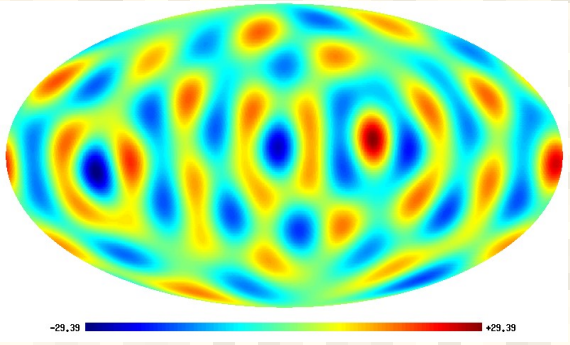

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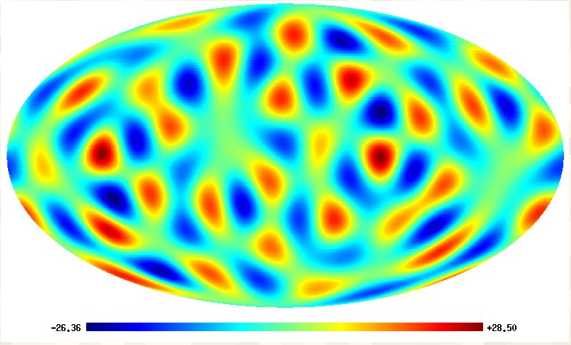

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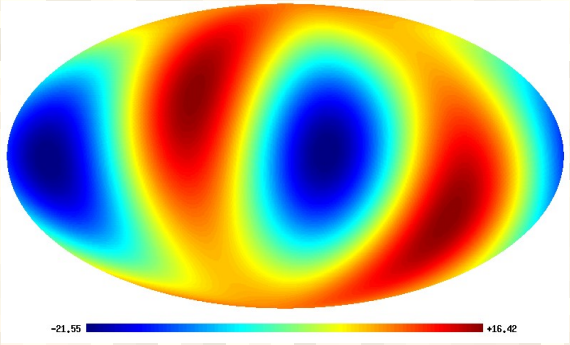
Низкие мультиполи у WMAP



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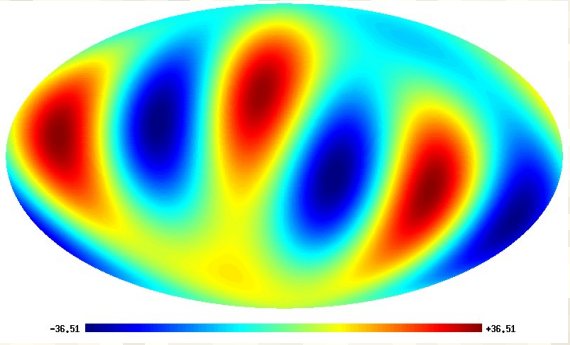

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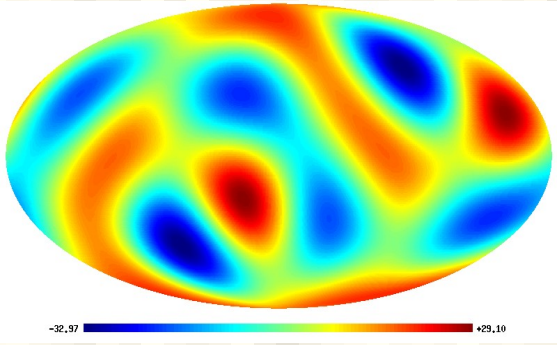

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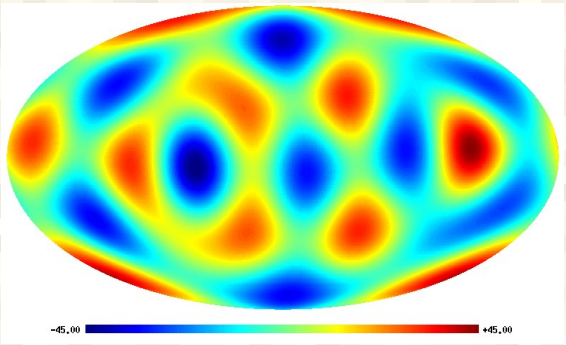

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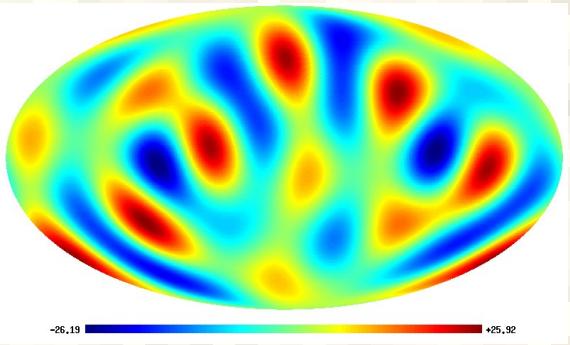

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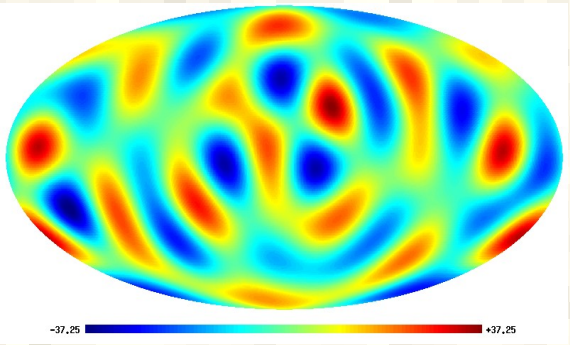

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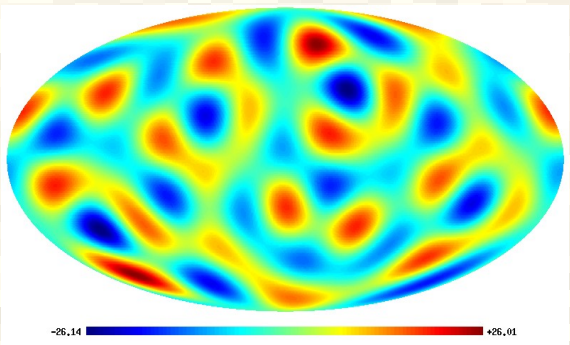

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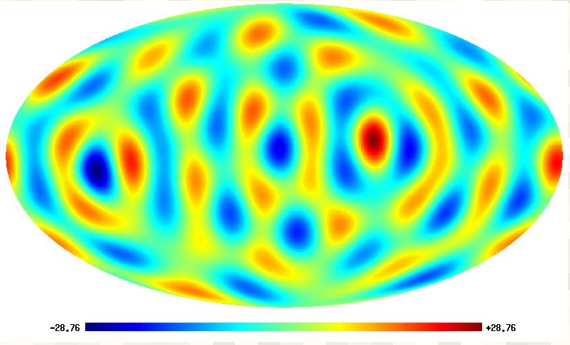

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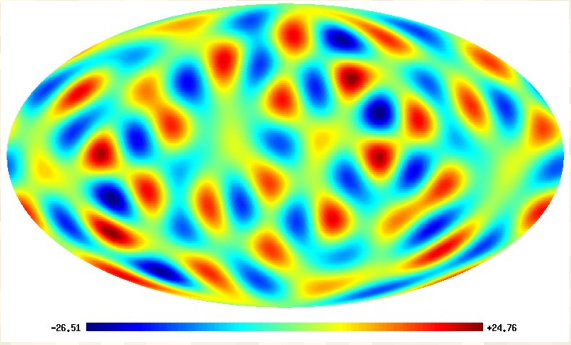
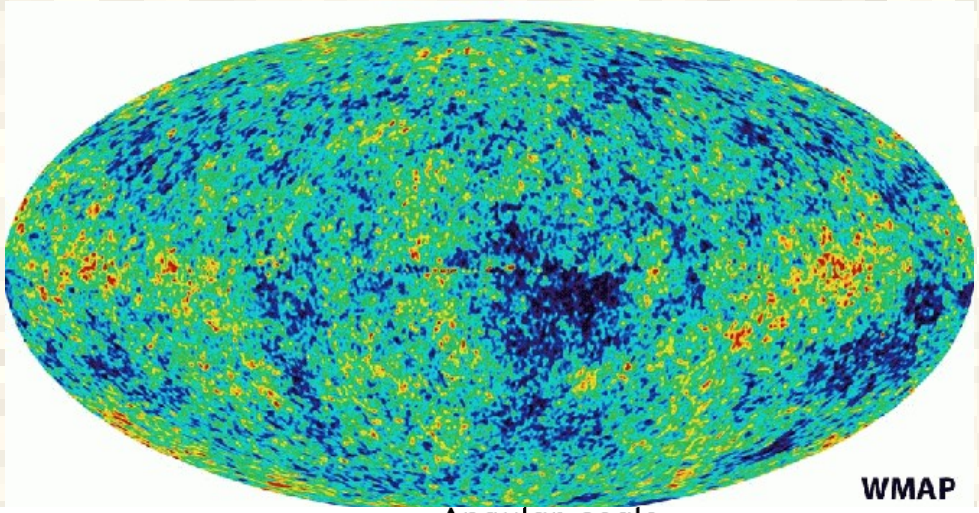


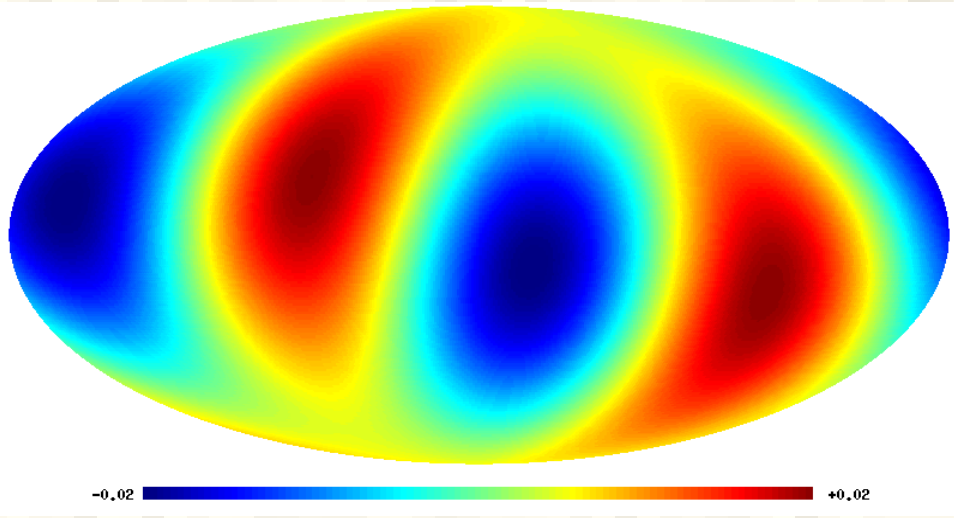
L=10

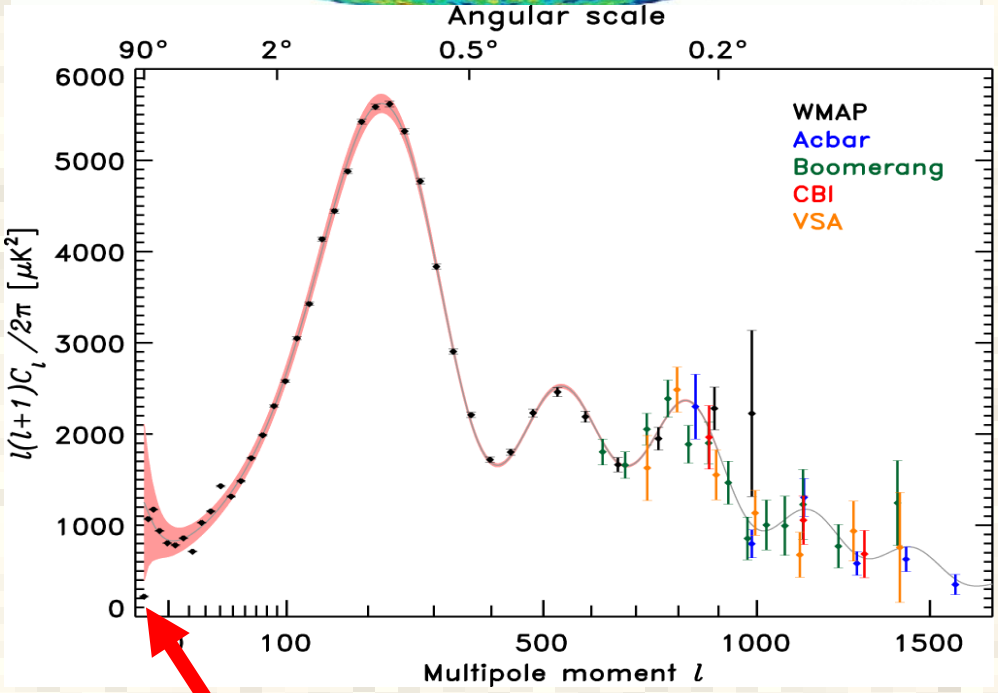
Пройдемся по некоторым аномалиям...

Ось **Зла**

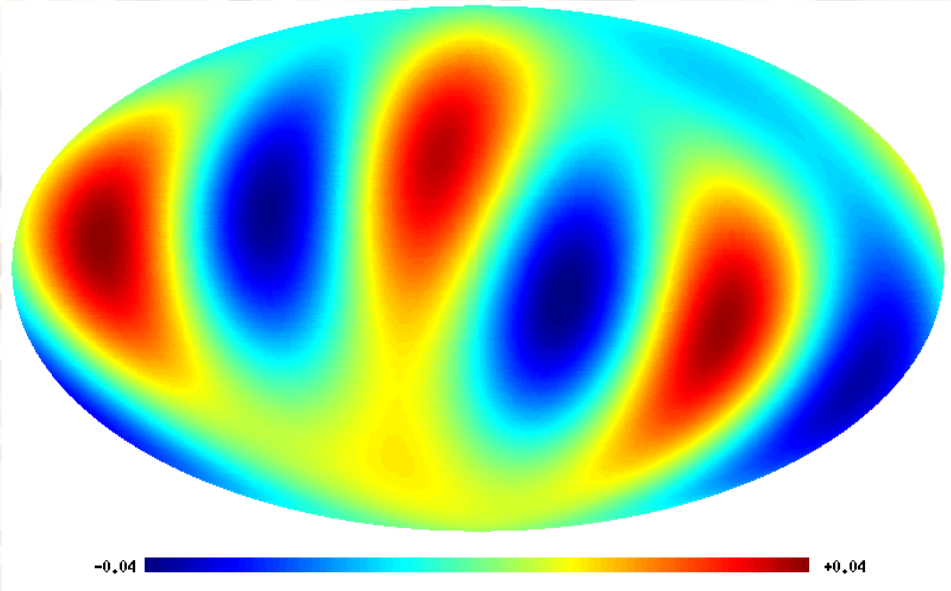
Проблемы квадруполя WMAP



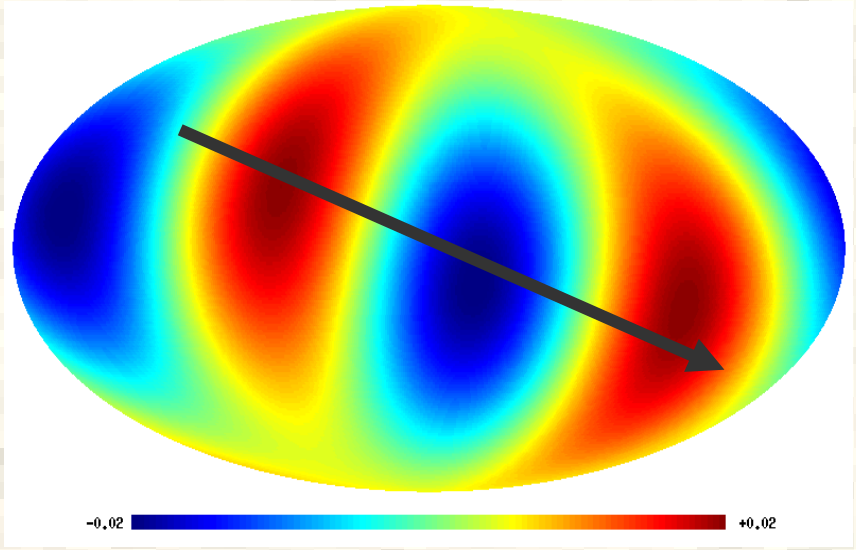




Амплитуда



Ось Зла: планарность + выравнивание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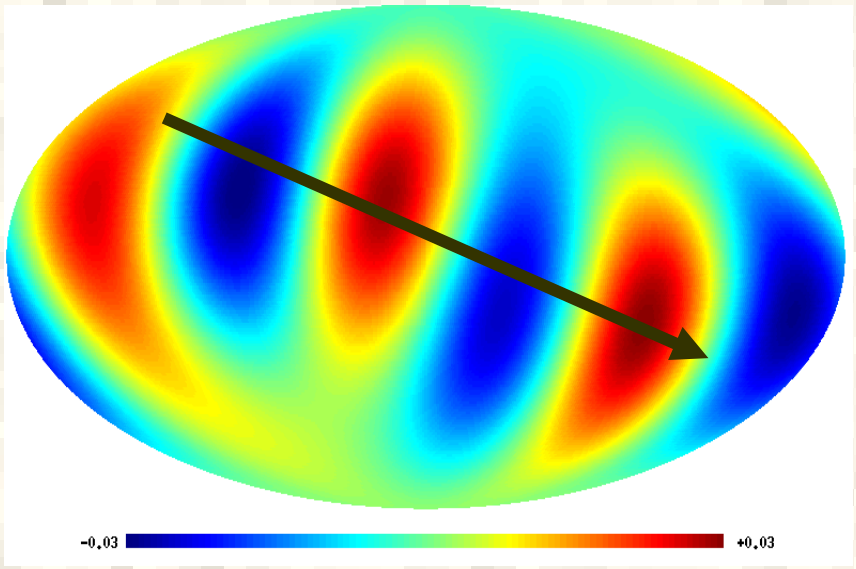
+0.02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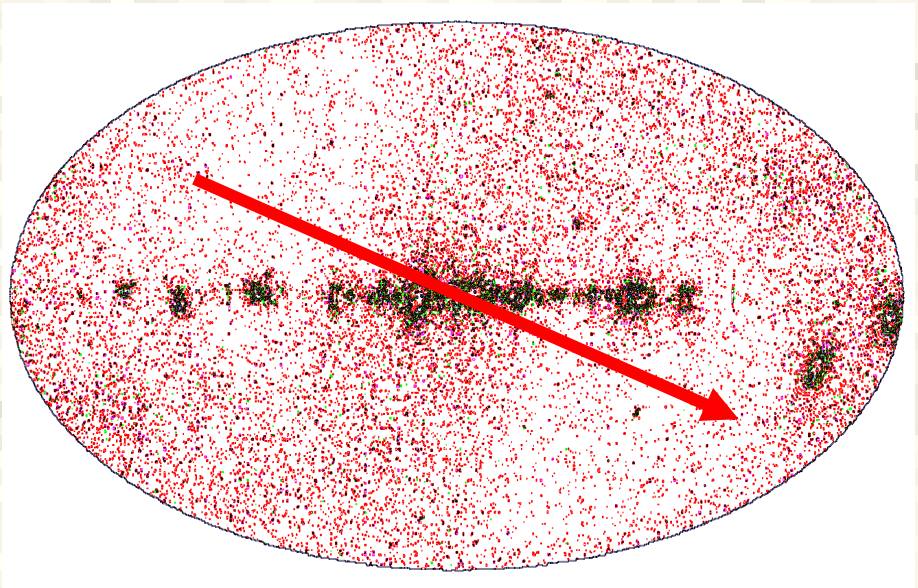
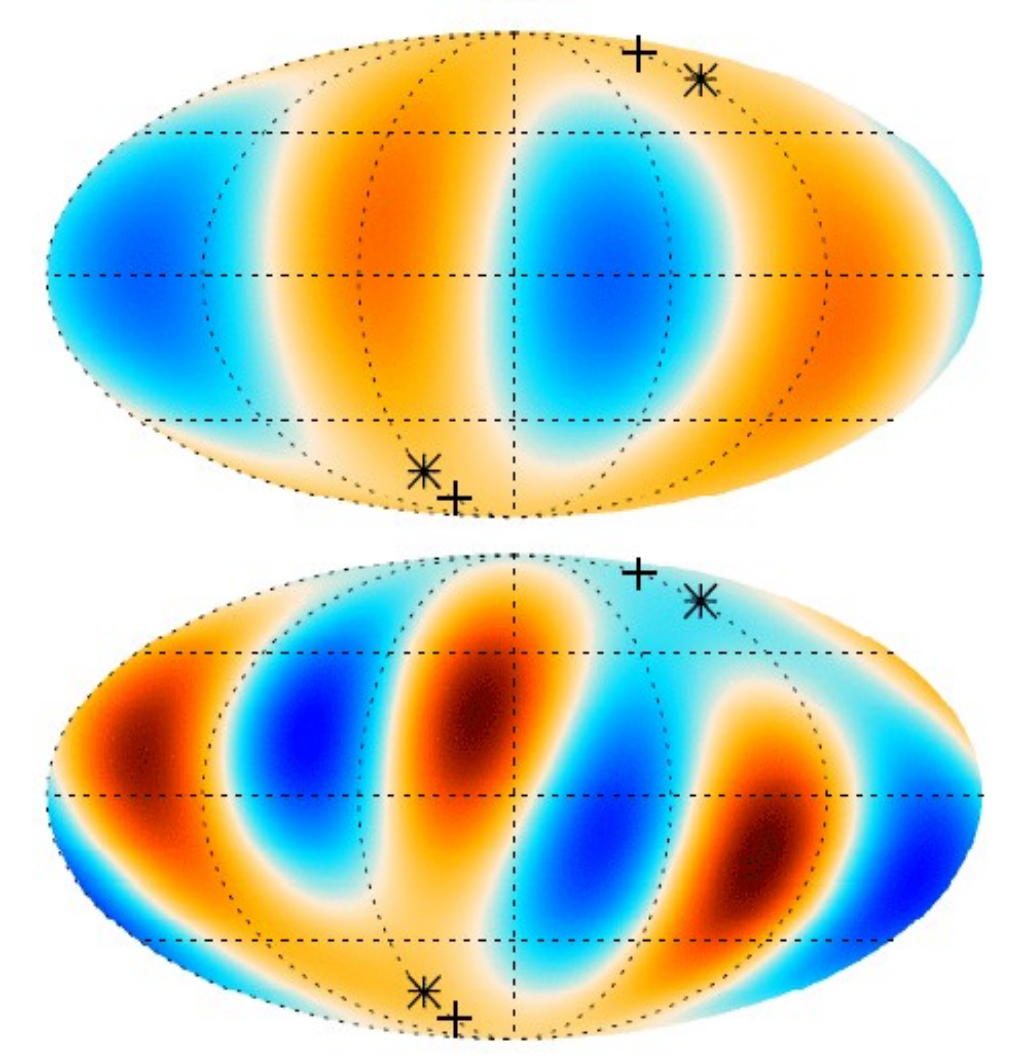


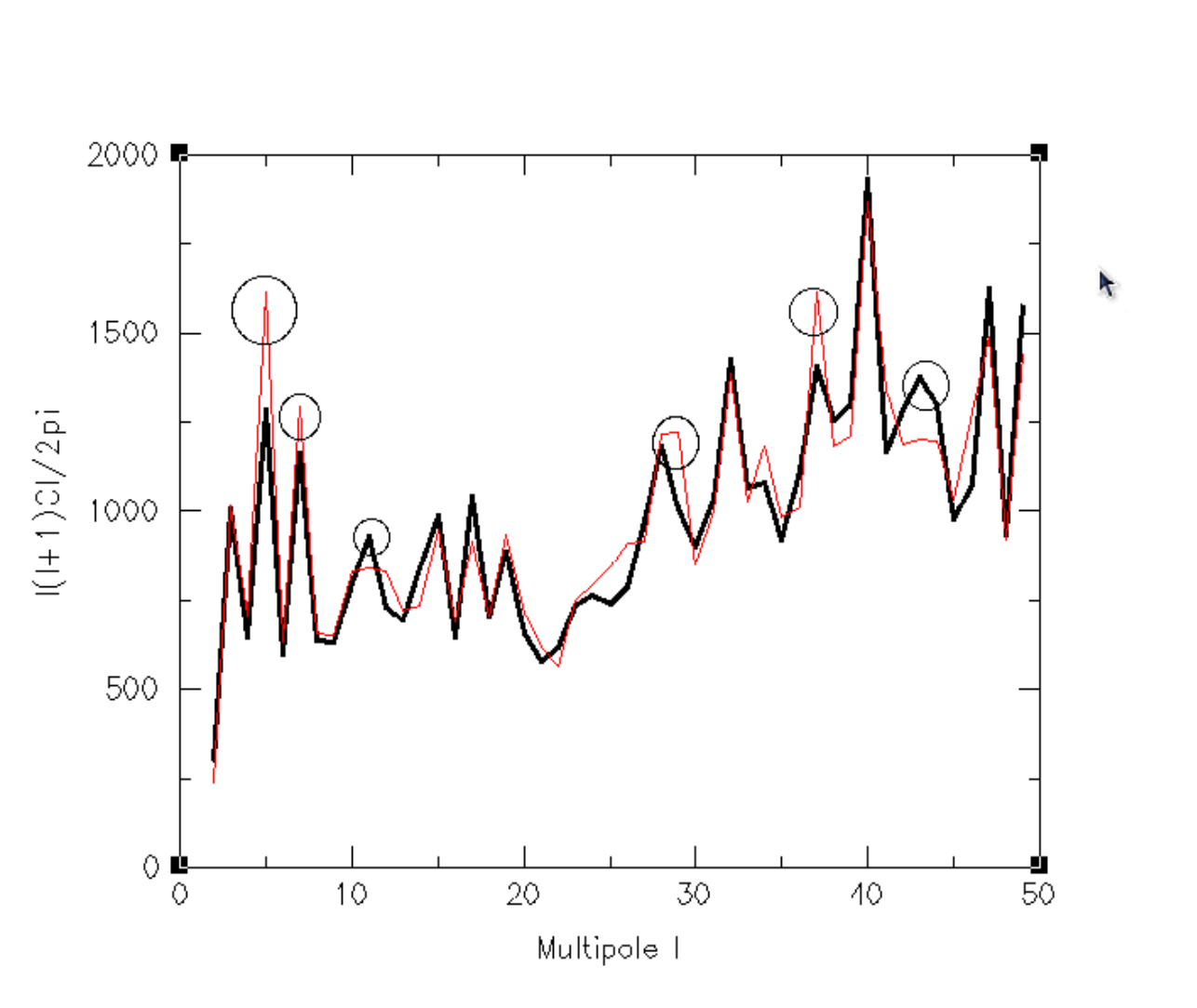
Ось Зла

(данные Planck)



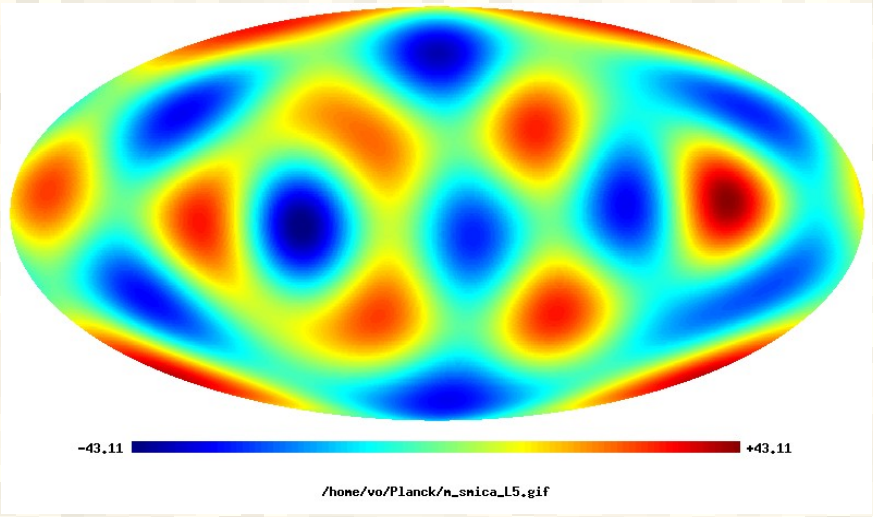
Угловой спектр мощности и отдельные гармоники

Спектр мощности C(l), l<=50



Planck, WMAP

L=5



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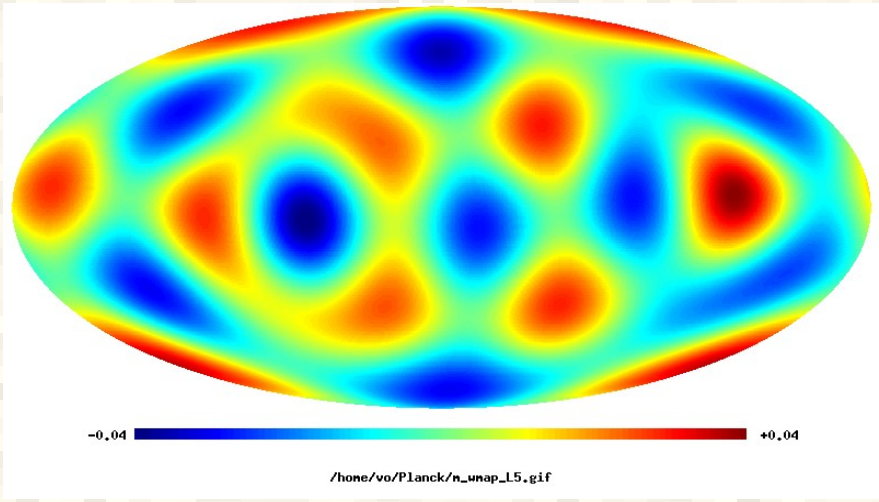

Planck, SMICA

WMAP

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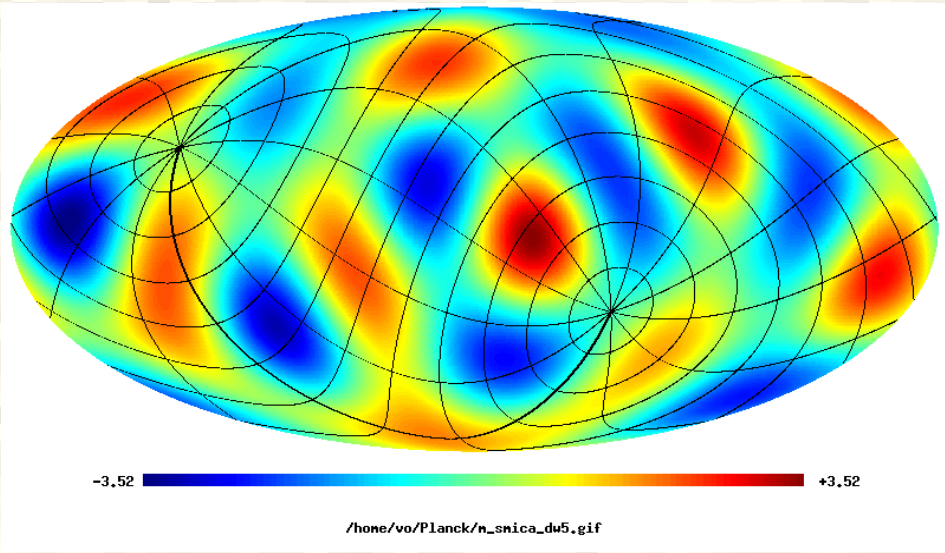

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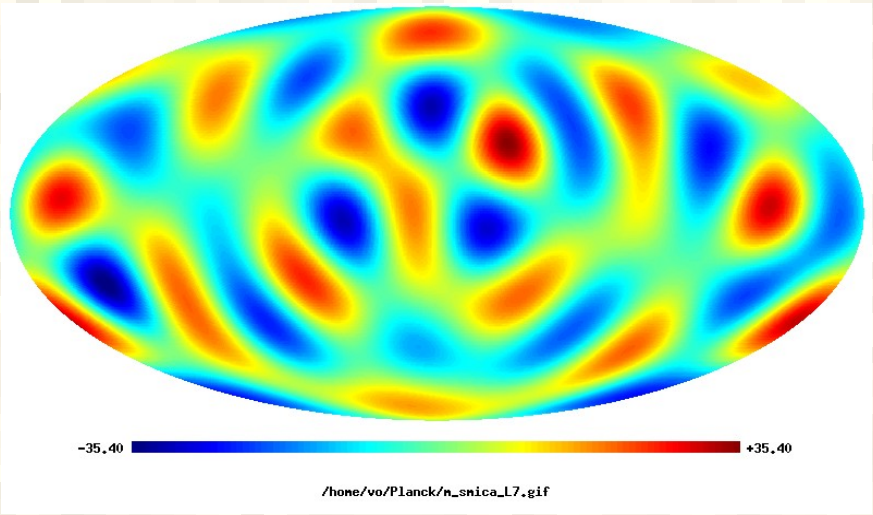

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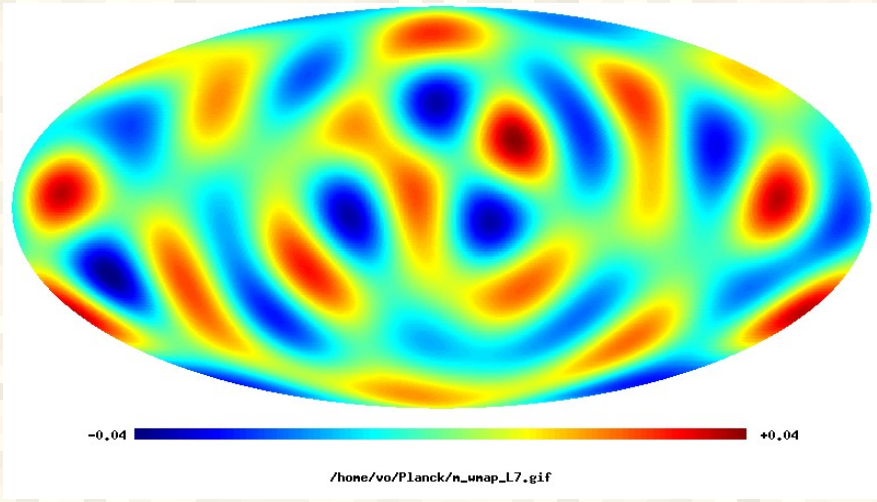

Planck, SMICA

WMAP

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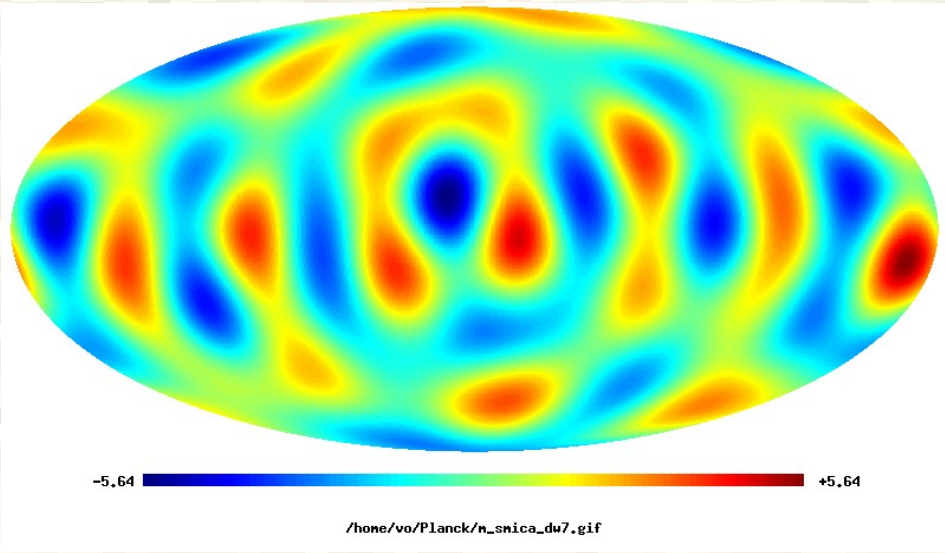
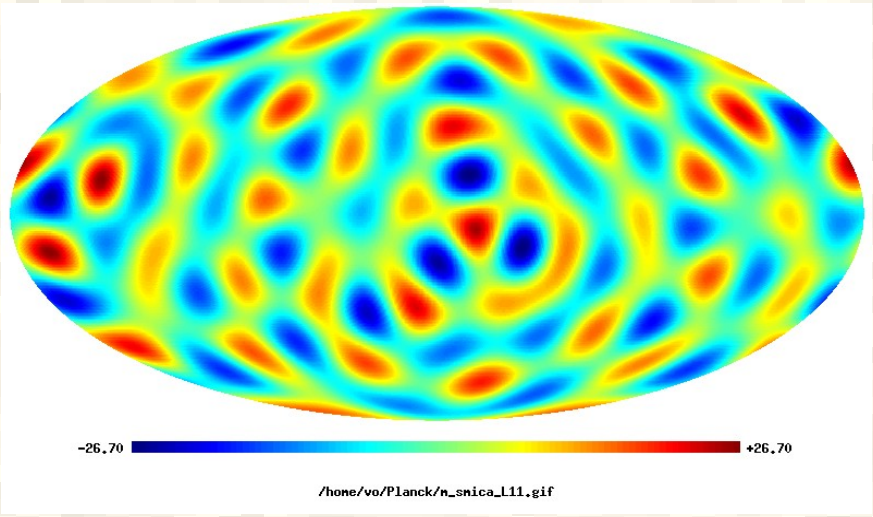
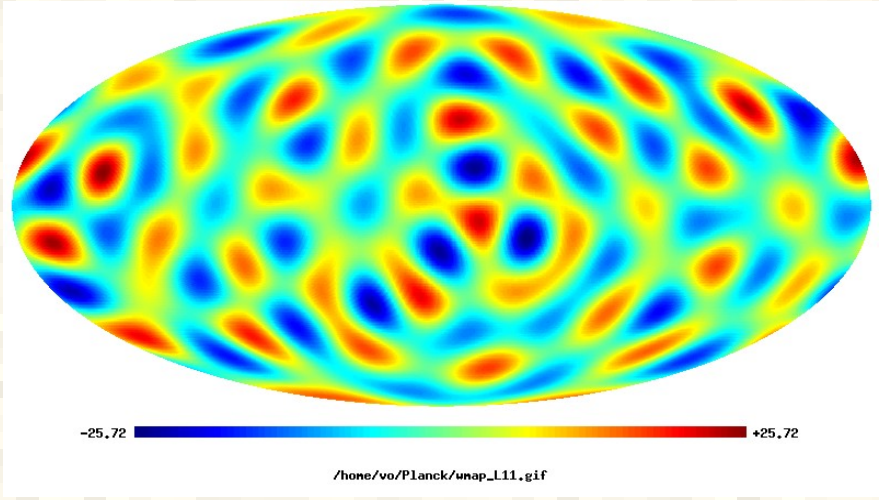


L=11



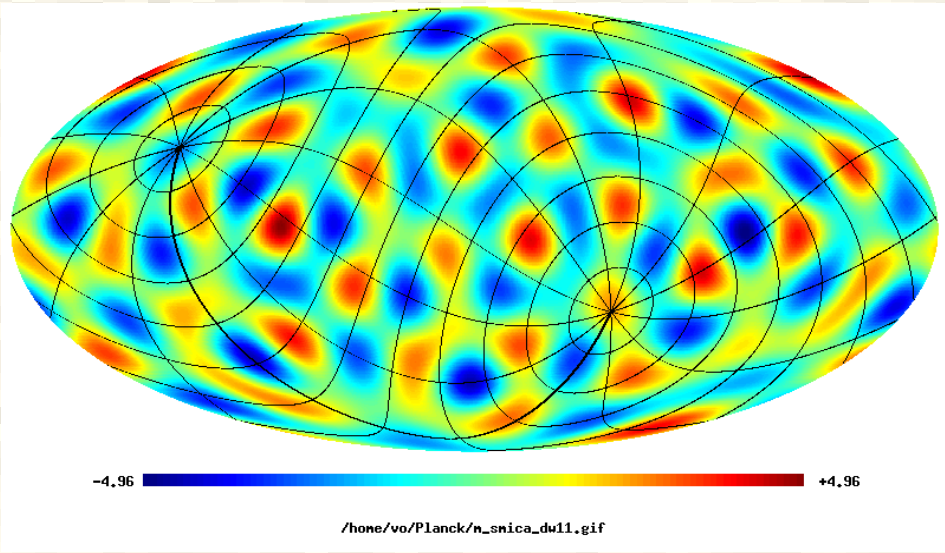
-



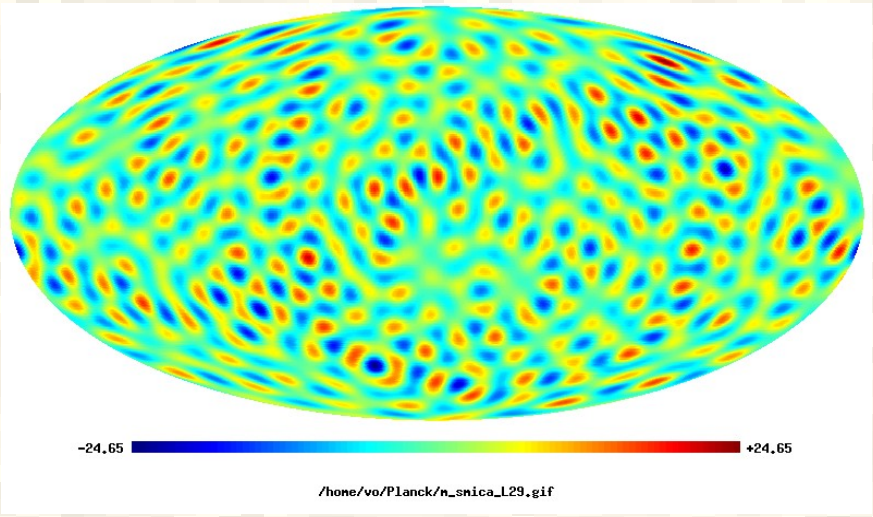
Planck, SMICA

WMAP

=



L=29



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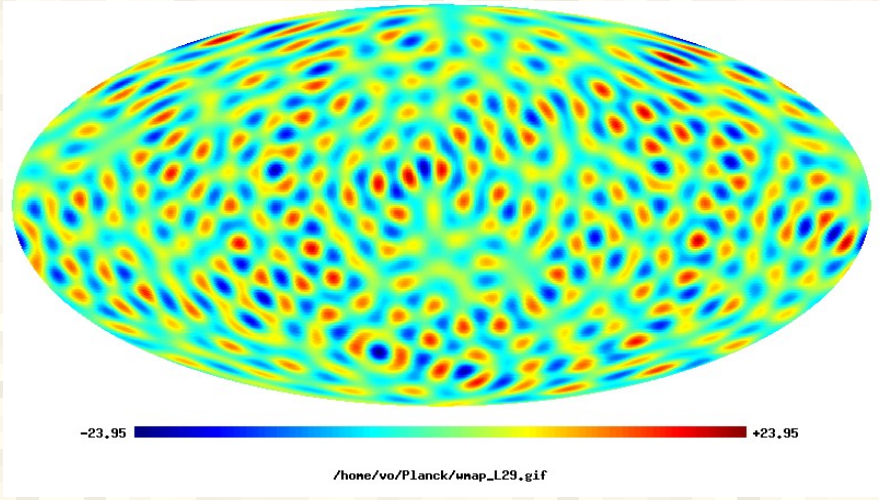
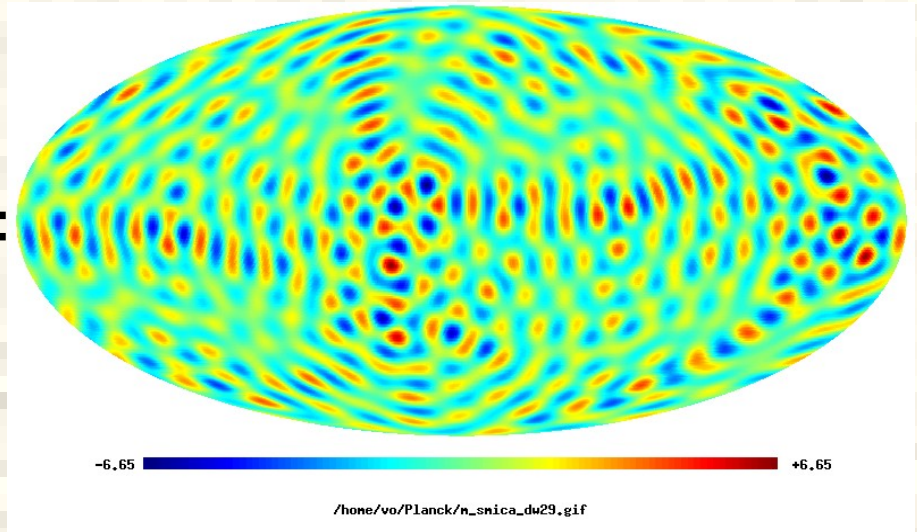


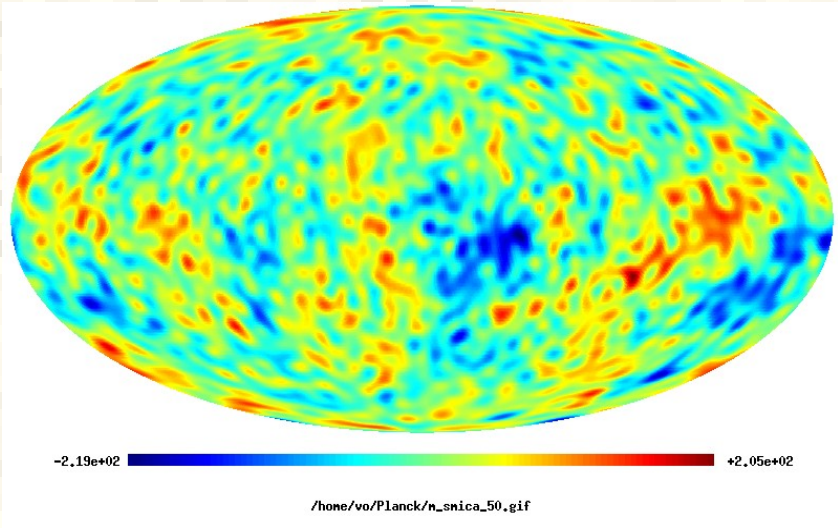
Planck, SMICA

WMAP

=



cp.:



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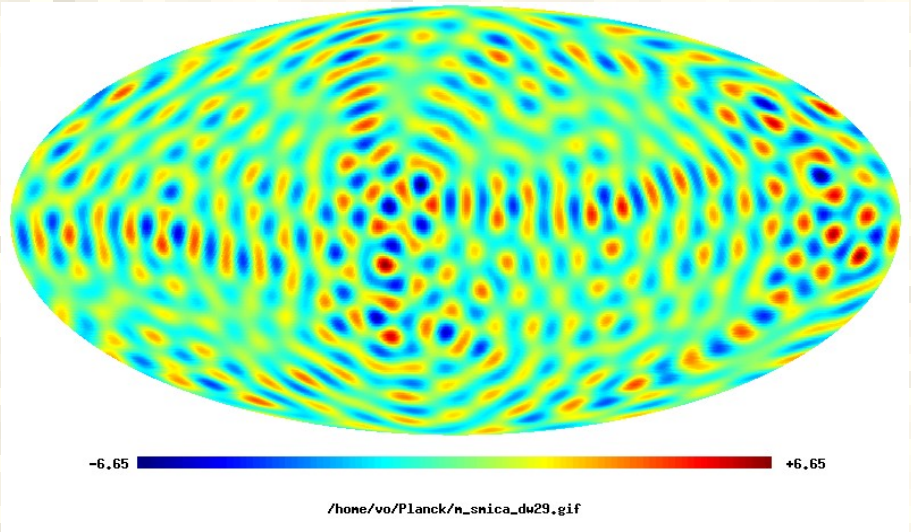
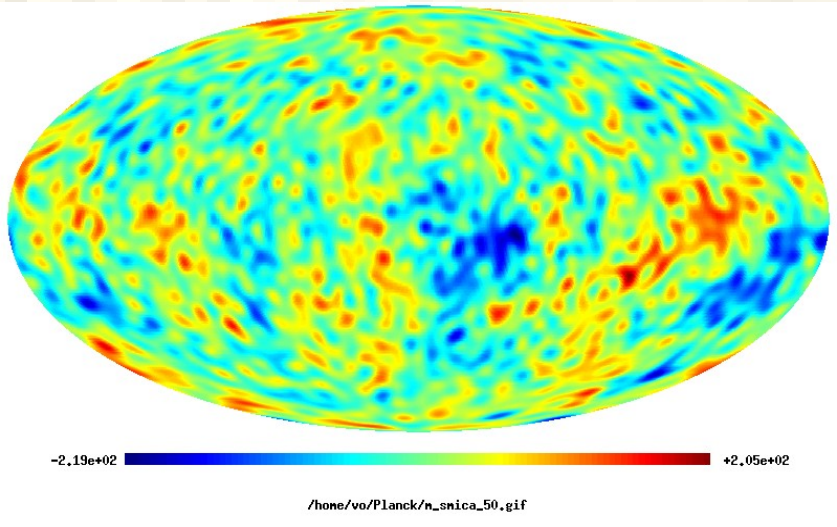
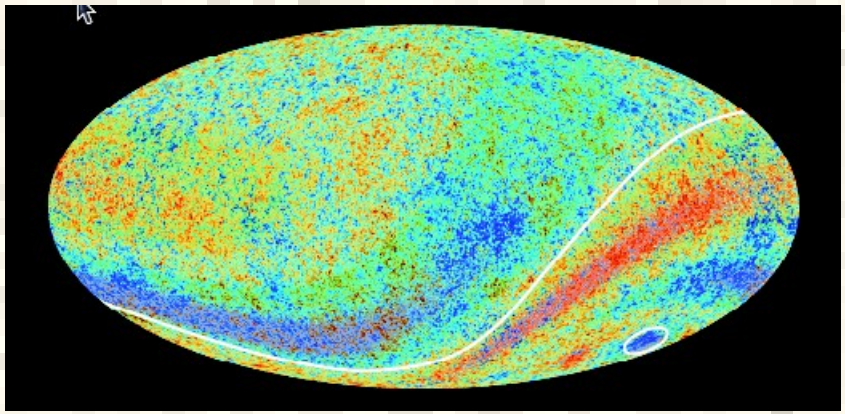


Planck-WMAP (L=29)

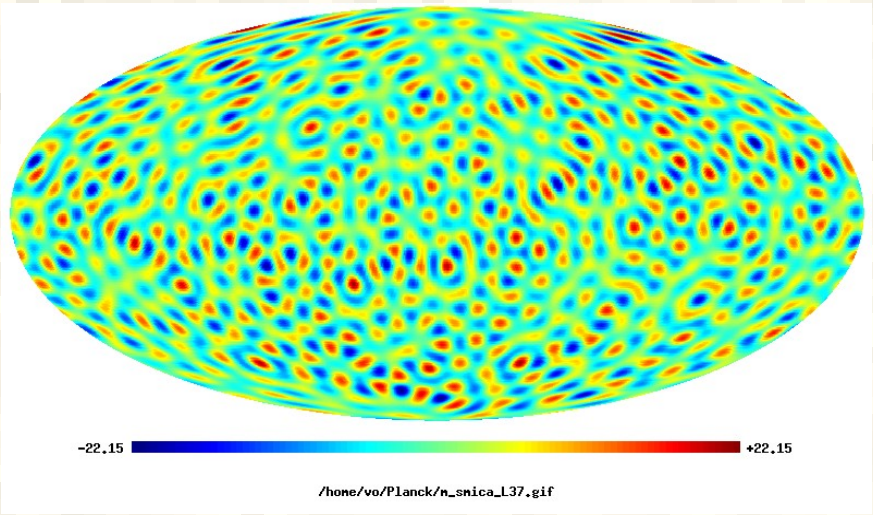


SMICA

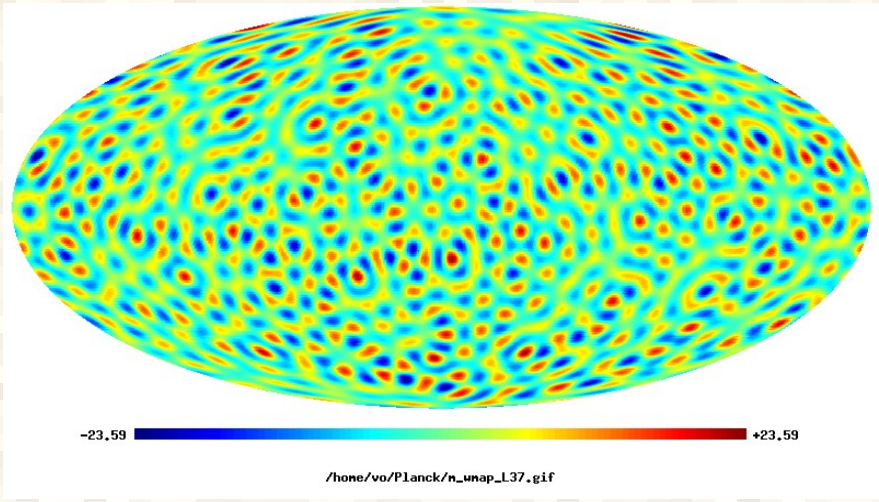


Bianchi VIIh

L=37



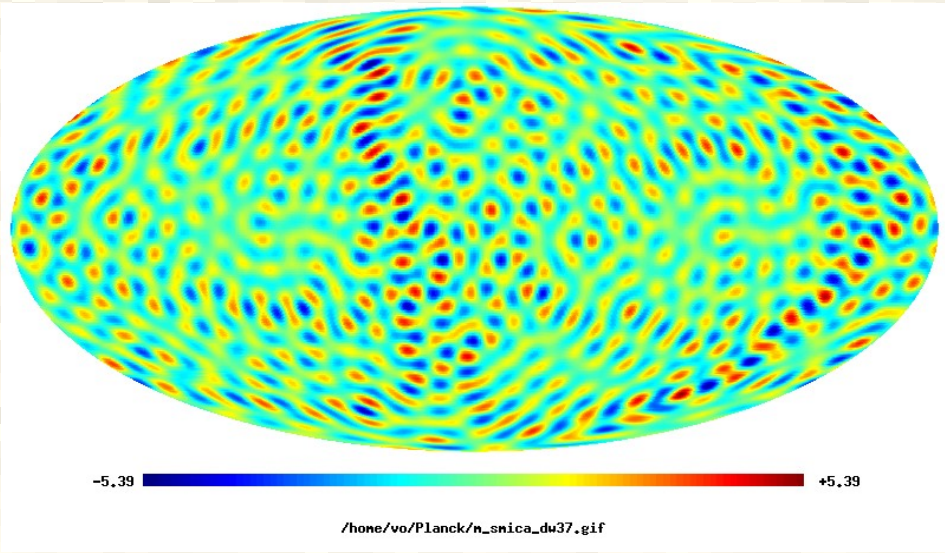
-



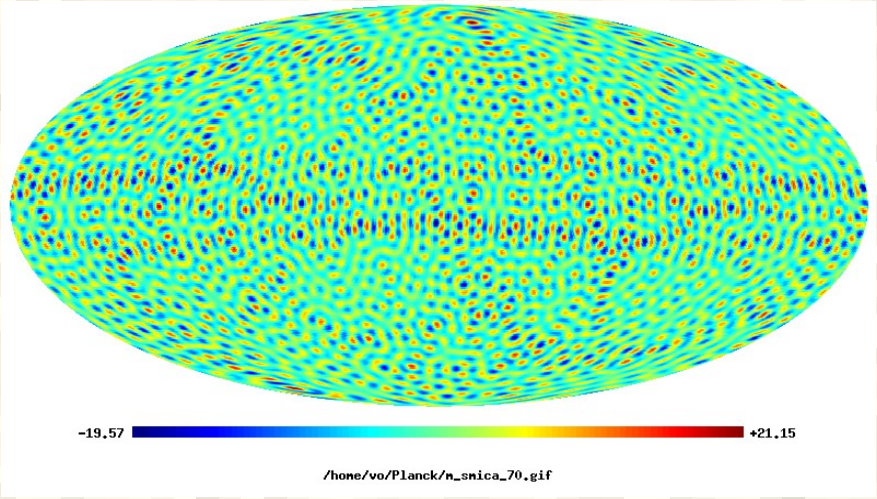
Planck, SMICA

WMAP

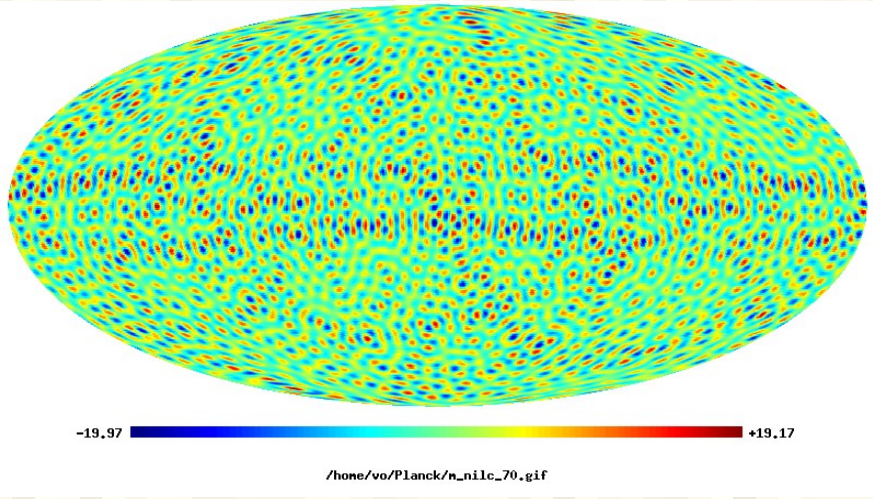
=



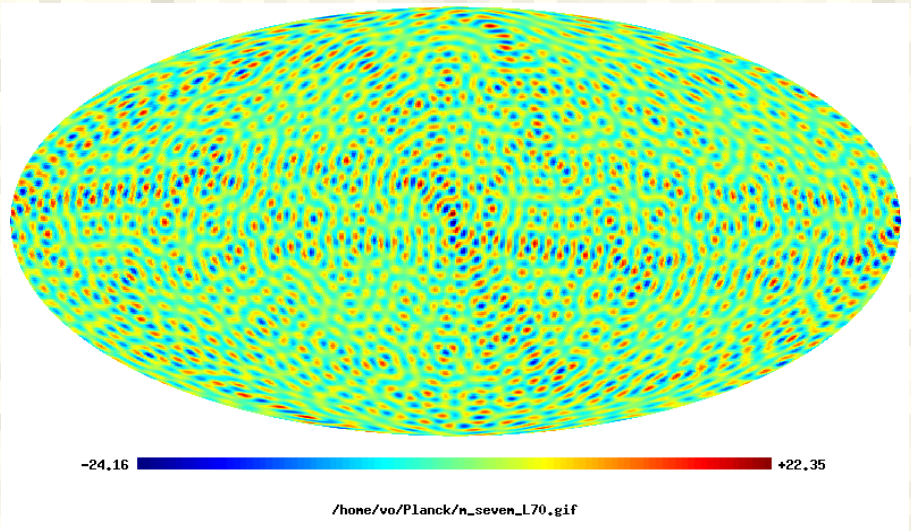
L=70



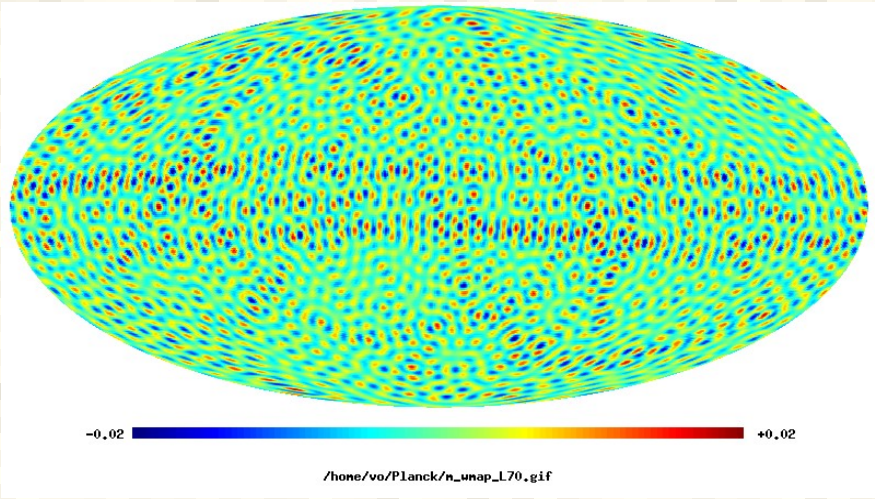
Planck, SMICA



NILC



SEVEM



WMAP

Космология
с эффектом Зельдовича-Сюняева

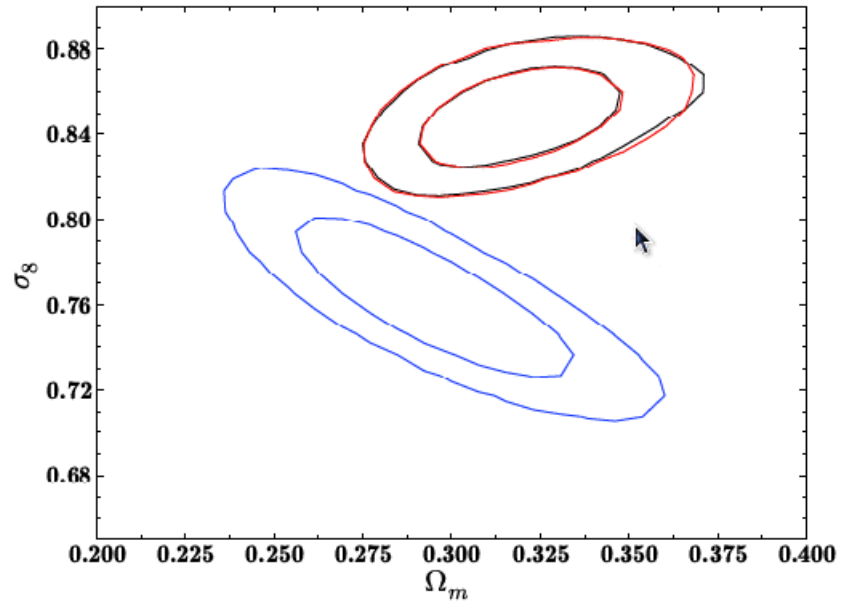
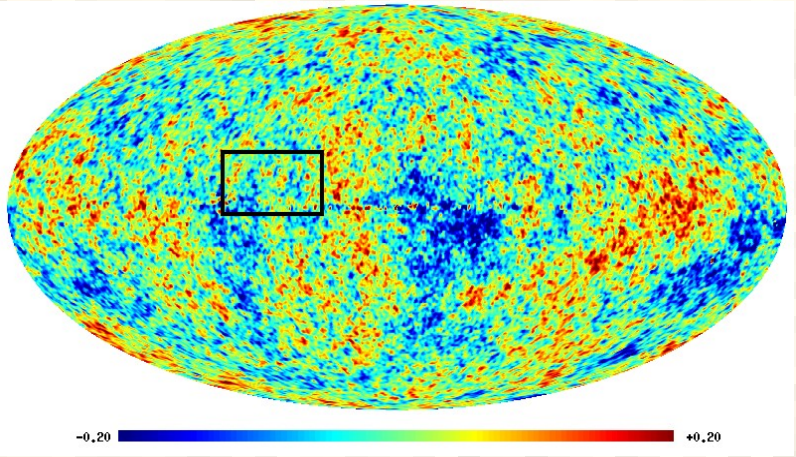
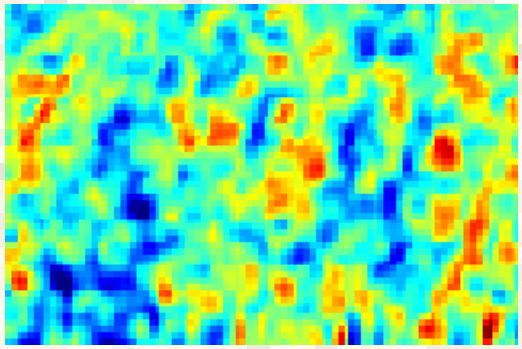


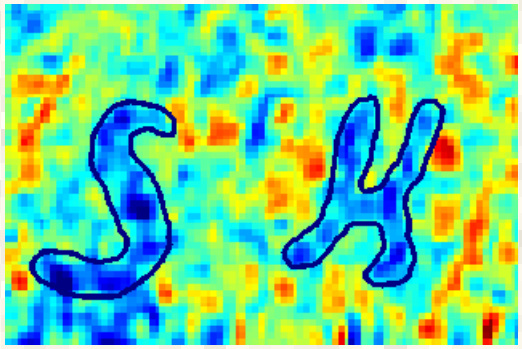
Fig. 11. 2D Ω_m–σ_8 likelihood contours for the analysis with *Planck* CMB only (red); *Planck* SZ + BAO + BBN (blue); and the combined *Planck* CMB + SZ analysis where the bias $(1 - b)$ is a free parameter (black).

Stephen Hawking «stamp»

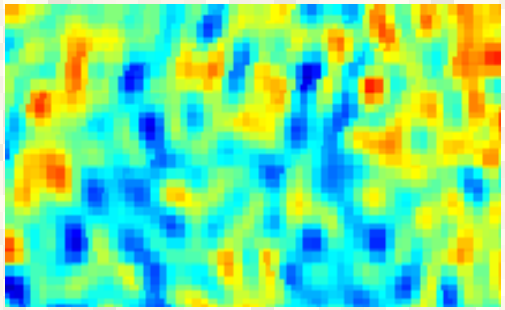
WMAP

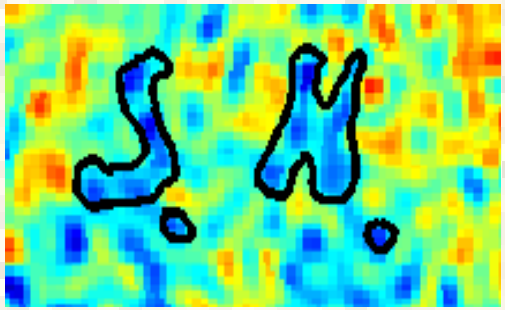






Planck,SMICA

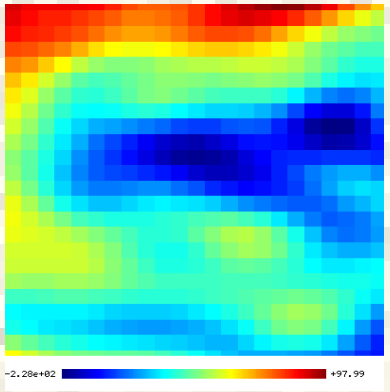




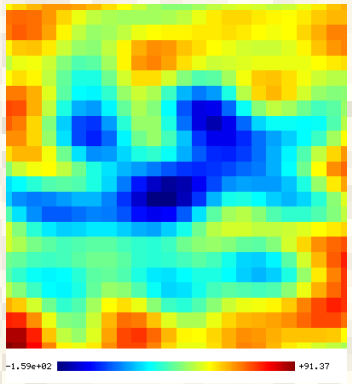
Неучтенные источники в картах Planck-a:
объекты RC-каталога с крутыми радиоспектрами

Дополнительный источник вторичной анизотропии:
>20 тыс. радиогалактик ?

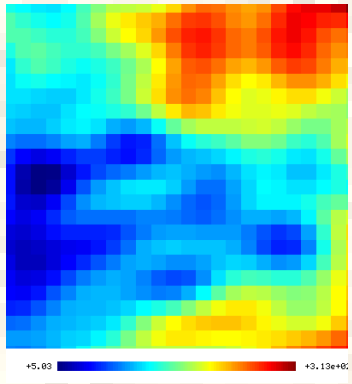
0015+0501

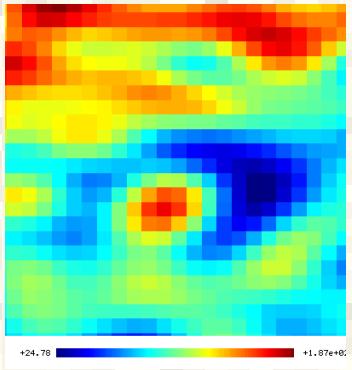


0226+0512



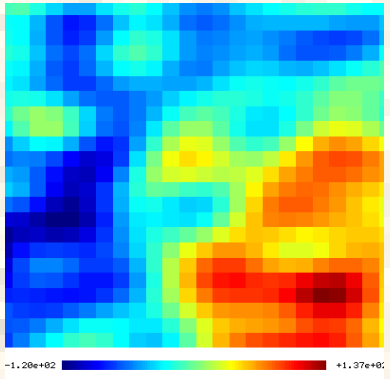
0311+0507, z=4.514



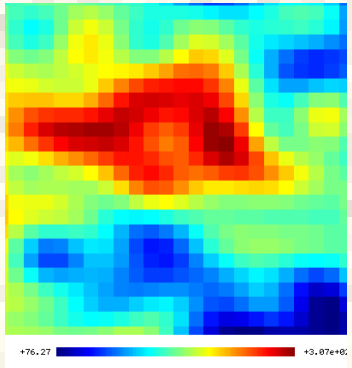


1113+0436
RG в скоплении ?

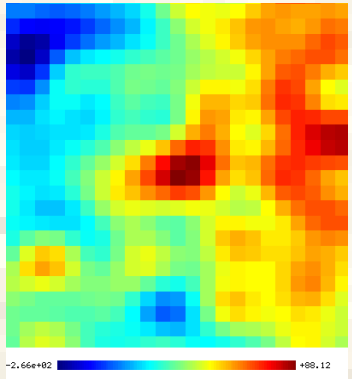
0225+0506



0302+0456



0427+0457

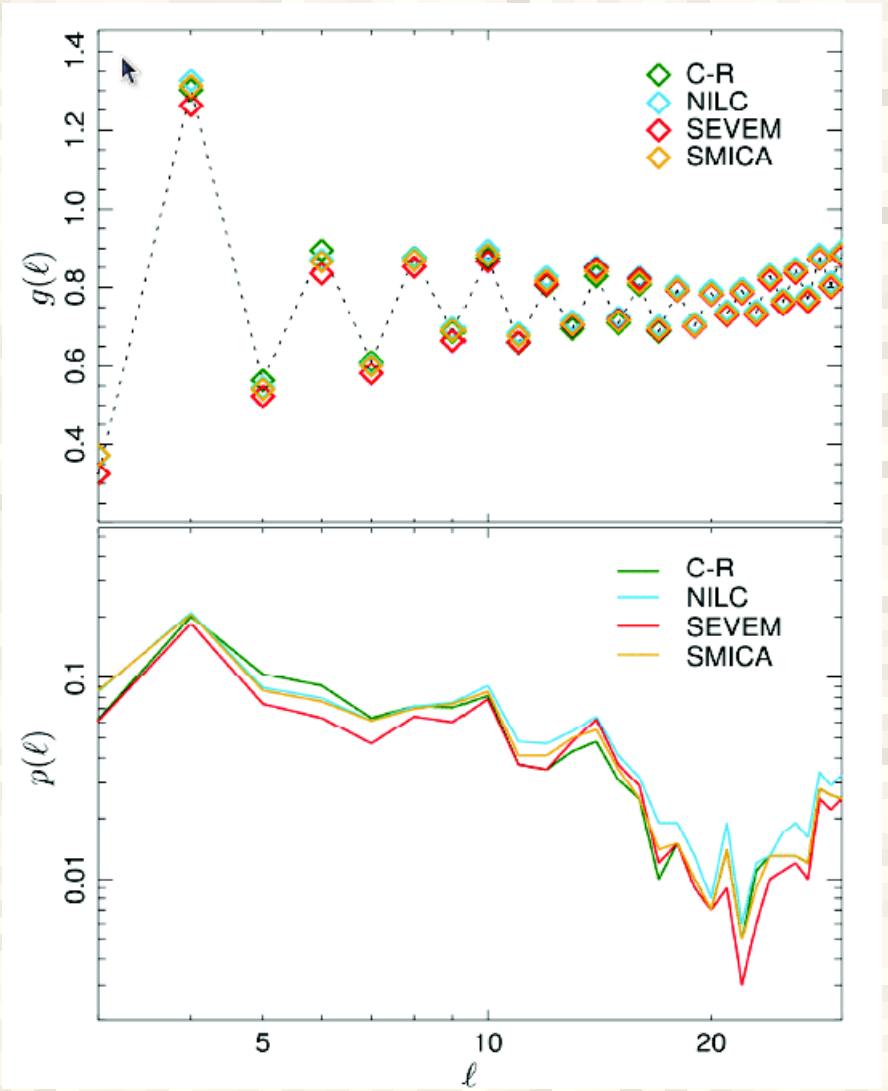


Четность/нечетность спектра мощности

$$P^{+}(\ell) = \sum_{n=2}^{\ell} \Gamma^{+}(n) \frac{n(n+1)}{2\pi} C_n,$$

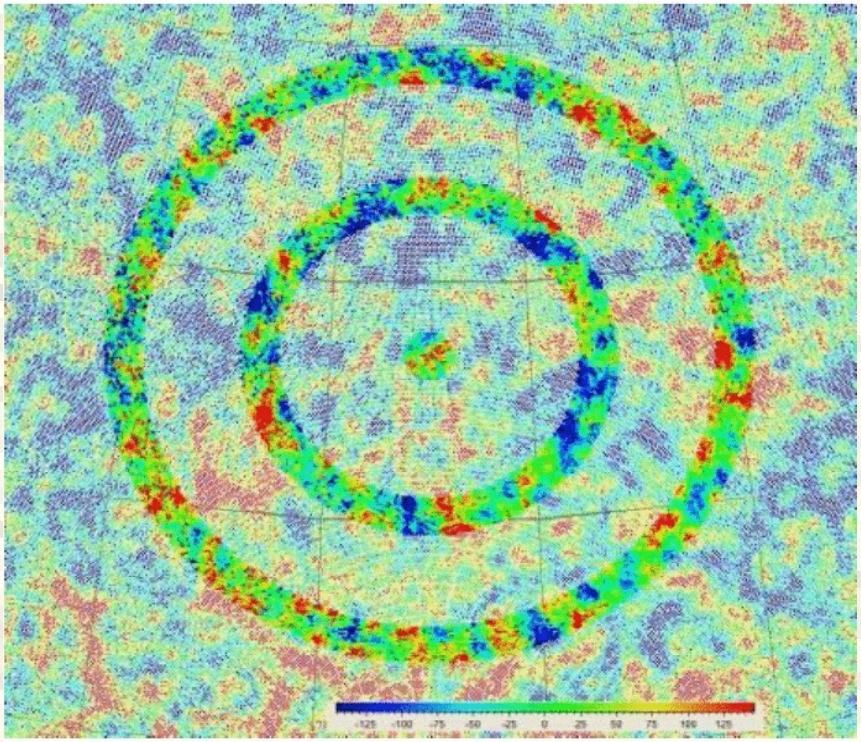
$$P^{-}(\ell) = \sum_{n=2}^{\ell} \Gamma^{-}(n) \frac{n(n+1)}{2\pi} C_n,$$

$$g(\ell) = \frac{P^{+}(\ell)}{P^{-}(\ell)}$$

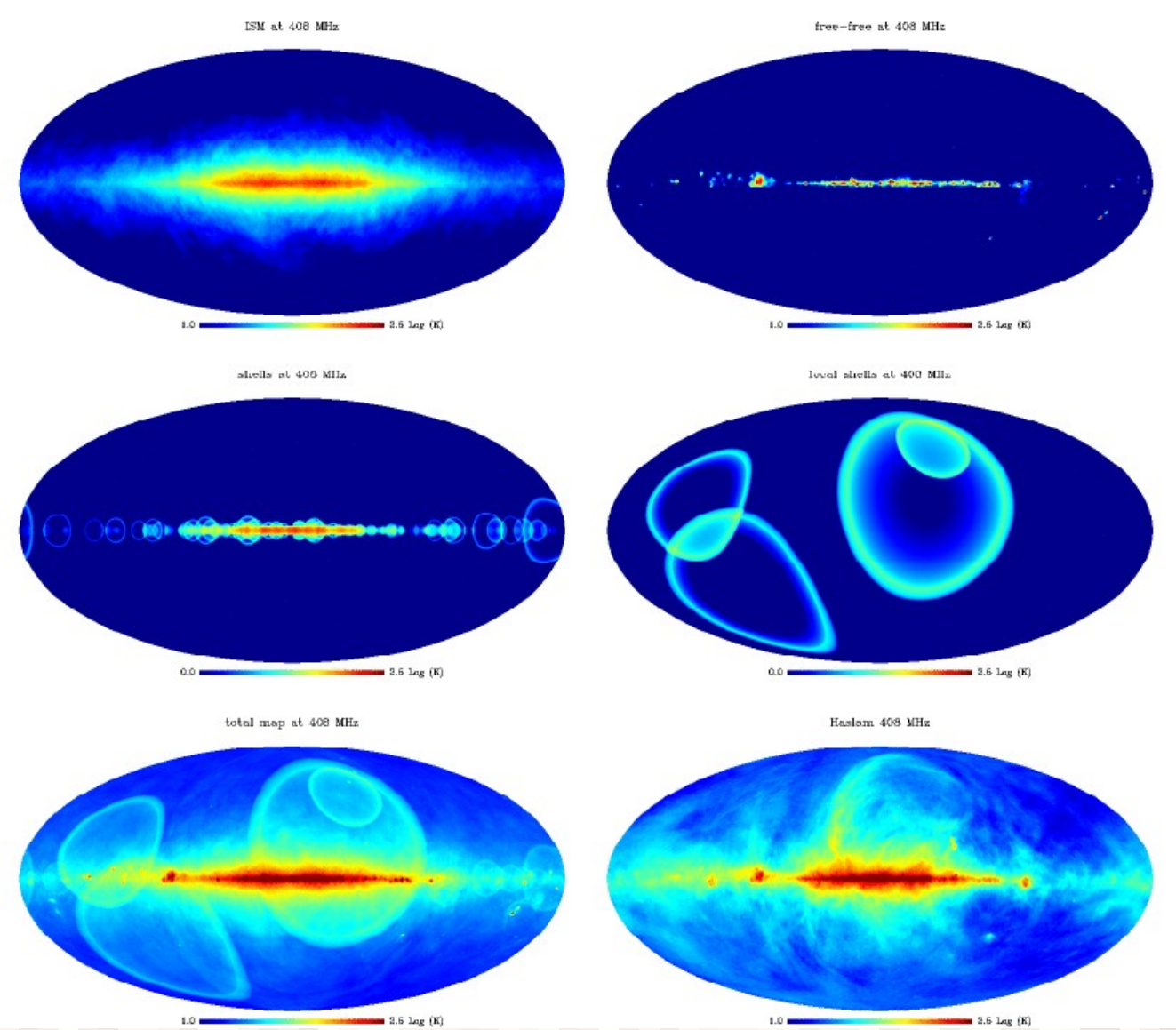


Круги

(Gurzadyan, Penrose, 2010)



Круги



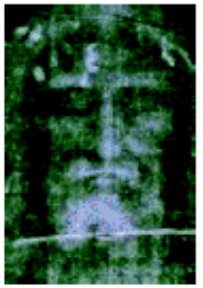
(Mertscha & Subir Sarkar, arXiv:1304.1078)

Не круги на CMB

(Zuntz,Zibin,Zunckel,Zwart,

2011,arXiv:1103.6262

1st April)

Description	Symbol
Pattern A: The happy-face smiley. Included for its wide cultural and scientific usage. Unicode symbol 0x263a	
Pattern B: The sad-face smiley. Included for comparison with symbol A. Unicode symbol 0x2639	
Pattern C: The face of Jesus from the Turin shroud. Included because it seems to crop up all over the place. Does not have a unicode symbol.	
Pattern D: The satanic pentagram symbol. Included for comparison with symbol C. Unicode 6 symbol 0x26E6.	
Pattern E: The look of disapproval. Included for recent cultural significance. Unicode symbols 0xCA0 and 0x05F.	ಠ_ಠ

Космологические результаты WMAP9 и Planck

http://lambda.gsfc.nasa.gov

Comparison of *Planck*-only and *WMAP*-only Six-Parameter ΛCDM Fits[a]

Parameter	*Planck* ("CMB+Lens")	*WMAP* (9-year)	Difference value	Difference *WMAP* σ
$\Omega_b h^2$	0.02217 ± 0.00033	0.02264 ± 0.00050	-0.00047	0.9
$\Omega_c h^2$	0.1186 ± 0.0031	0.1138 ± 0.0045	0.0048	1.1
Ω_Λ	0.693 ± 0.019	0.721 ± 0.025	-0.028	1.1
τ	0.089 ± 0.032	0.089 ± 0.014	0	0
t_0 (Gyr)	13.796 ± 0.058	13.74 ± 0.11	56 Myr	0.5
H_0 (km s^{-1}Mpc^{-1})	67.9 ± 1.5	70.0 ± 2.2	-2.1	1.0
σ_8	0.823 ± 0.018	0.821 ± 0.023	0.002	0.1
Ω_b	0.0481[b]	0.0463 ± 0.0024	0.0018	0.7
Ω_c	0.257[b]	0.233 ± 0.023	0.024	1.0

Революции нет ... Так это *прекрасно* !

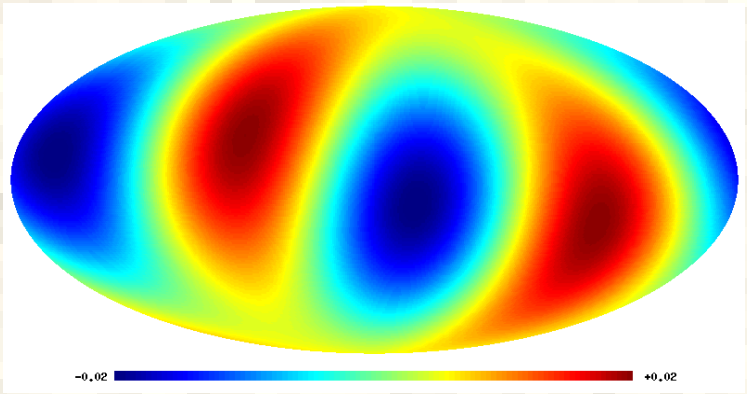
Приложения

Приложение 1.

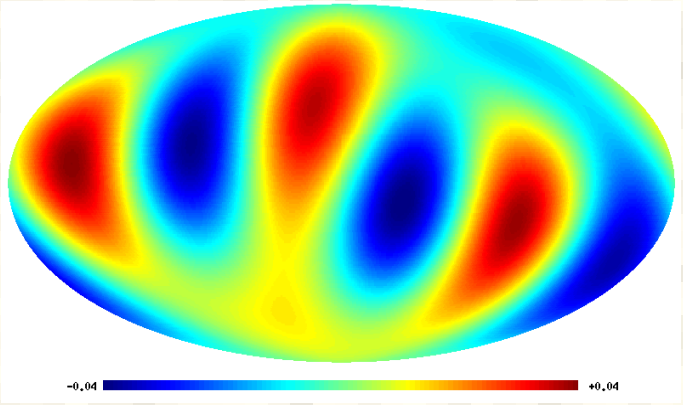
Мультипольное разложение

Multipole expansion

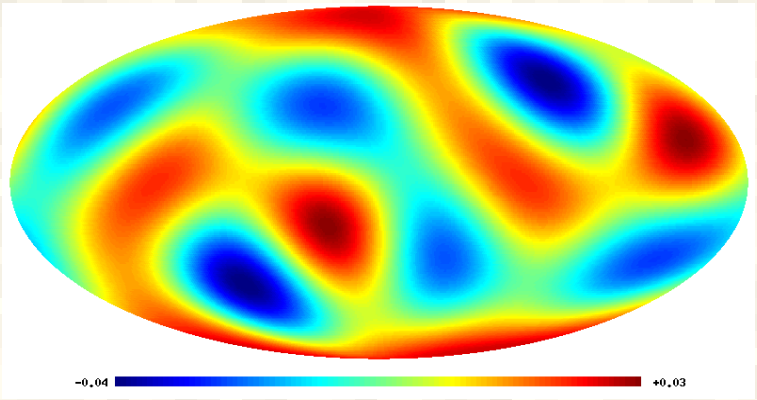
$$\Delta T(\theta,\phi) = \sum_{l=2}^{\infty} \sum_{m=-l}^{m=l} a_{l,m} Y_{l,m}(\theta,\phi)$$



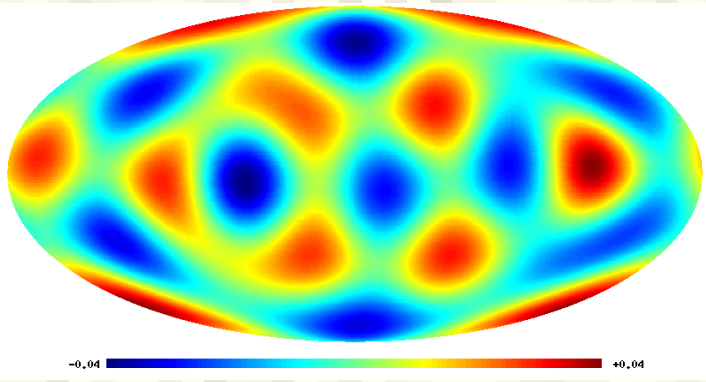
L = 2 (quadrupole)



L =3 (octupole)

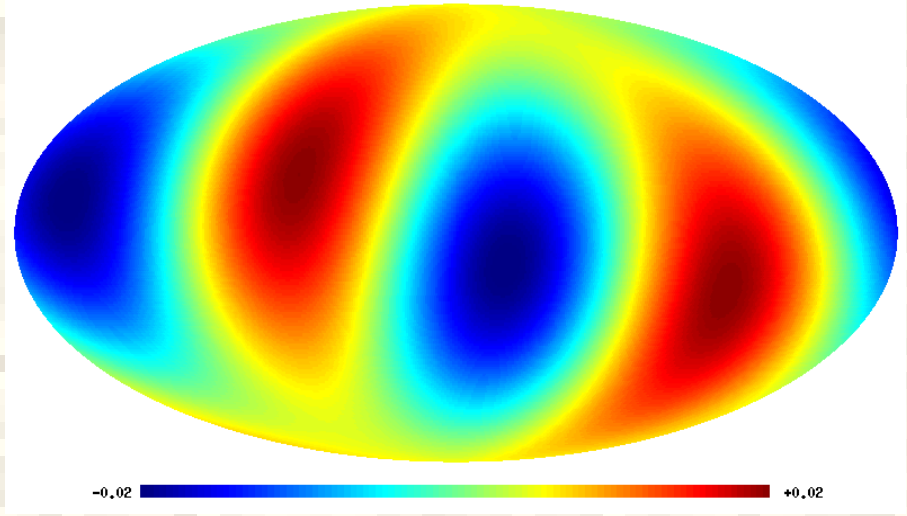


L = 4

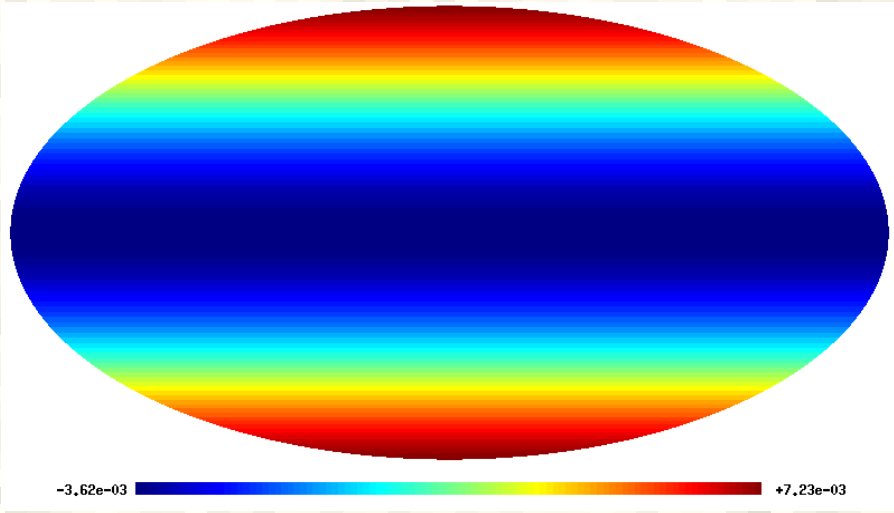


L = 5

Квадруполь



=

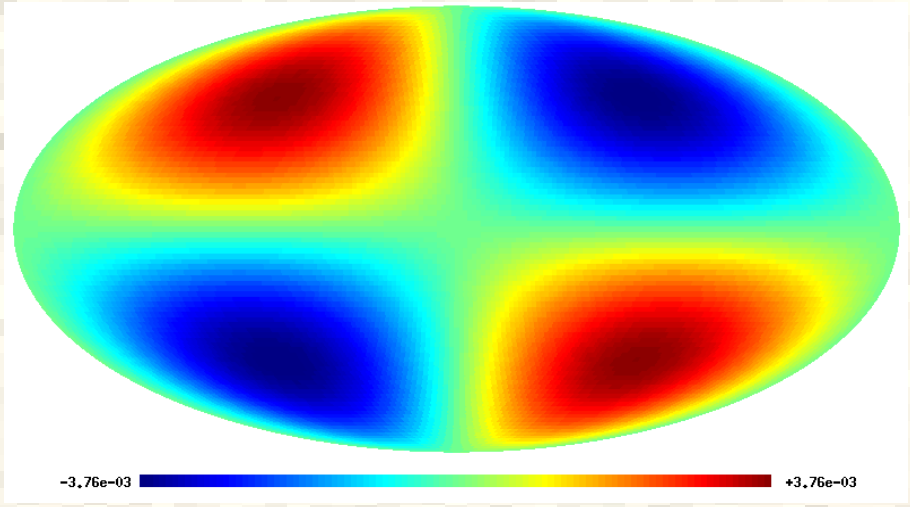


+

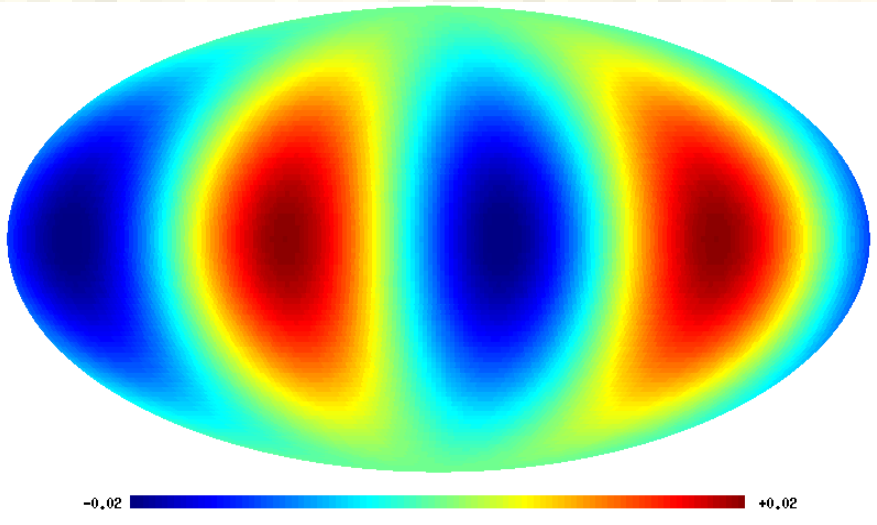
L=2

(2,0)

+



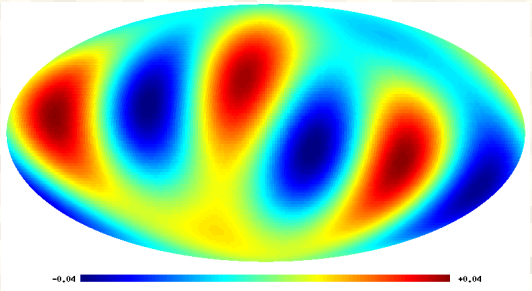
+



(2,1)

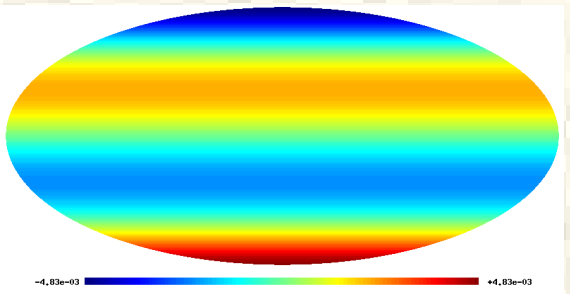
(2,2)

Октуполь



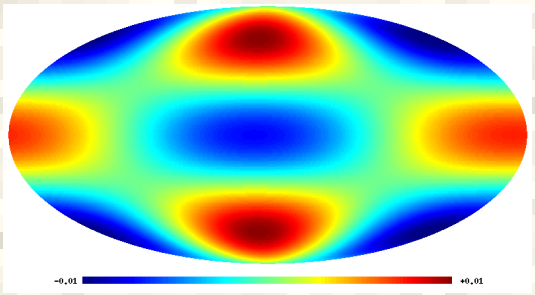
L=3

=



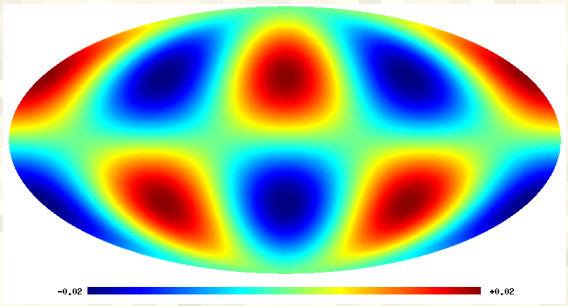
(3,0)

+



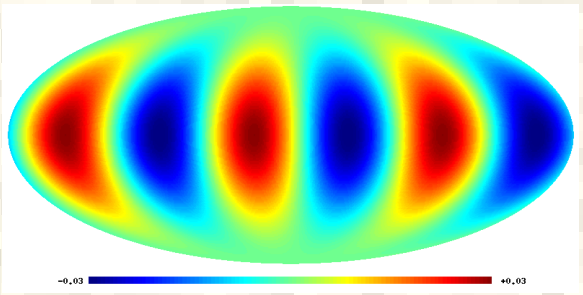
(3,1)

+



(3,2)

+



(3,3)

Приложение 2: негауссовость

Для простейшей инфляционной модели

Возмущения плотности -> возмущения CMB:

$$a_{\ell m} = 4(-i)^{\ell} \int \frac{d^3\mathbf{k}}{(2\pi)^3} \Phi(\mathbf{k}) g_{T\ell}(\mathbf{k}) Y_{\ell}^{*} m(\hat{\mathbf{k}})$$

Первичная негауссовость

$$\Phi(x) = \Phi_L(x) + f_{\mathrm{NL}}(\Phi^2(x) - \langle \Phi^2(x) \rangle)$$