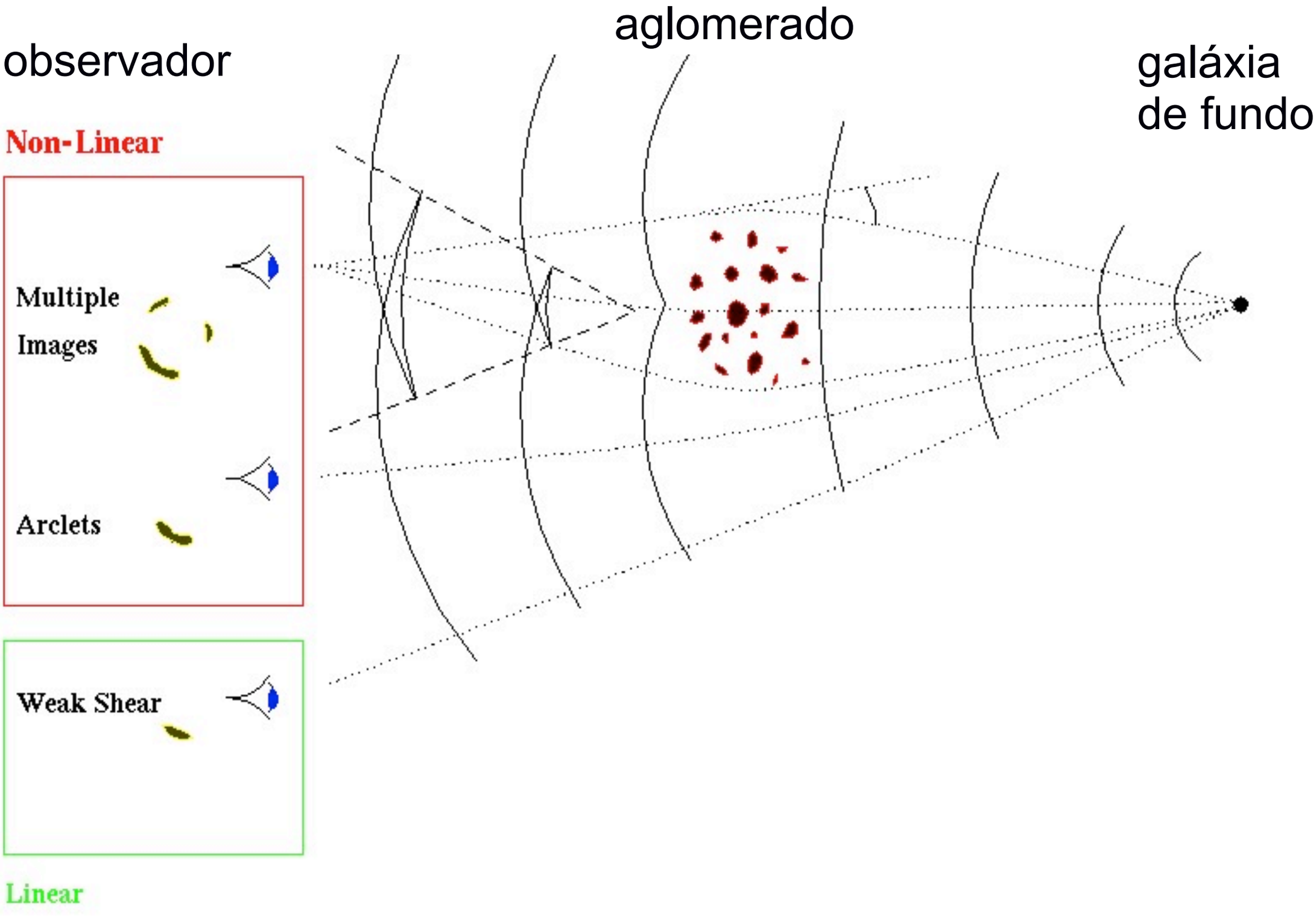
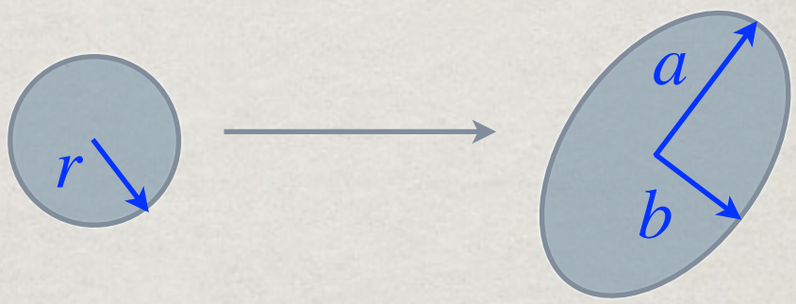
Lenteamento Gravitacional Fraco

Efeito fraco e forte de lente



Mapeamento Linear

- Fonte circular



$$a = \left(\frac{1}{1-\kappa-\gamma}\right) r$$

$$b = \left(\frac{1}{1-\kappa+\gamma}\right) r$$

- Magnificação

$$\mu = \frac{A_{\rm imagem}}{A_{\rm fonte}} = \left[(1-\kappa)^2 - \gamma^2\right]^{-1}$$

- Elipticidade

$$\epsilon := \frac{a-b}{a+b} = \frac{\gamma}{1-\kappa} =: g$$

Lenteamento Fraco

- Regime de lenteamento fraco

$$\epsilon = \epsilon_I = \epsilon_S + g$$

- "teorema fundamental do lenteamento fraco":

$$\boxed{\langle \epsilon \rangle = g}$$

- mas

$$g \ll \epsilon$$

- desafios observacionais, instrumentais, computacionais e teóricos!

Medindo o lenteamento fraco

- Sinal $\langle \varepsilon_I \rangle = \gamma \qquad (\varepsilon_I = \varepsilon_S + \gamma)$
- Ruído $\sigma_\varepsilon = \left\langle \left| {\varepsilon_S}^2 \right| \right\rangle^{1/2} \sim 0.3 \gg \gamma$
- Ganhar do ruído fazendo uma média em um grande número de galáxias

Regime	γ	$\gamma/\sigma_\varepsilon$	$N_{\rm gal}$ for S/N$\sim$ 1
weak lensing by clusters	0.03	0.1	10^2
galaxy-galaxy lensing	0.003	0.01	10^4
cosmic shear	0.001	0.003	10^5

Much more galaxies for precision measurements needed.

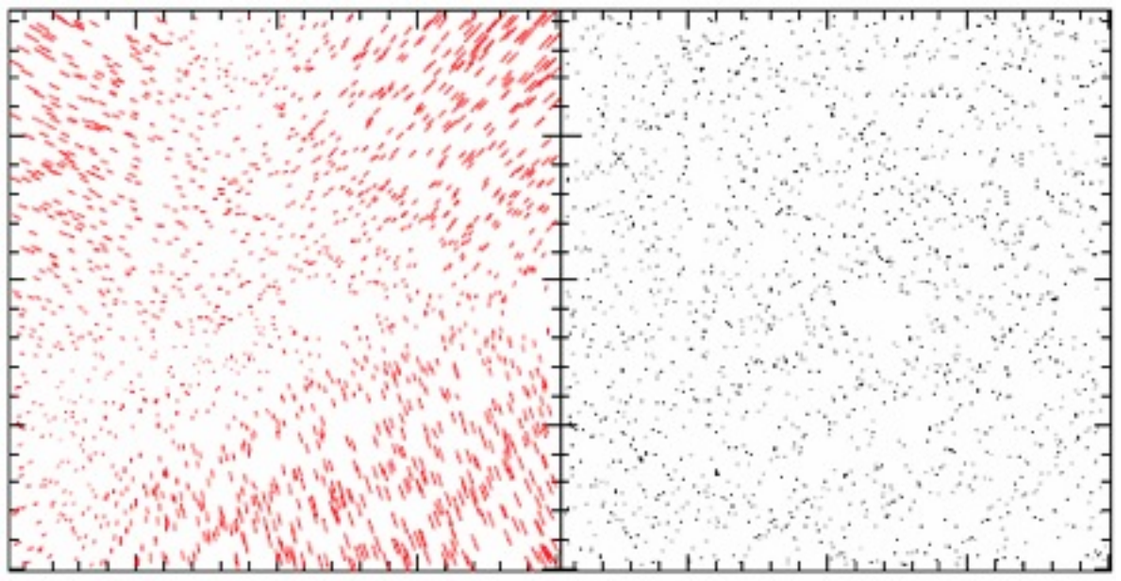
(de Kilbinger)

Desafíos Técnicos



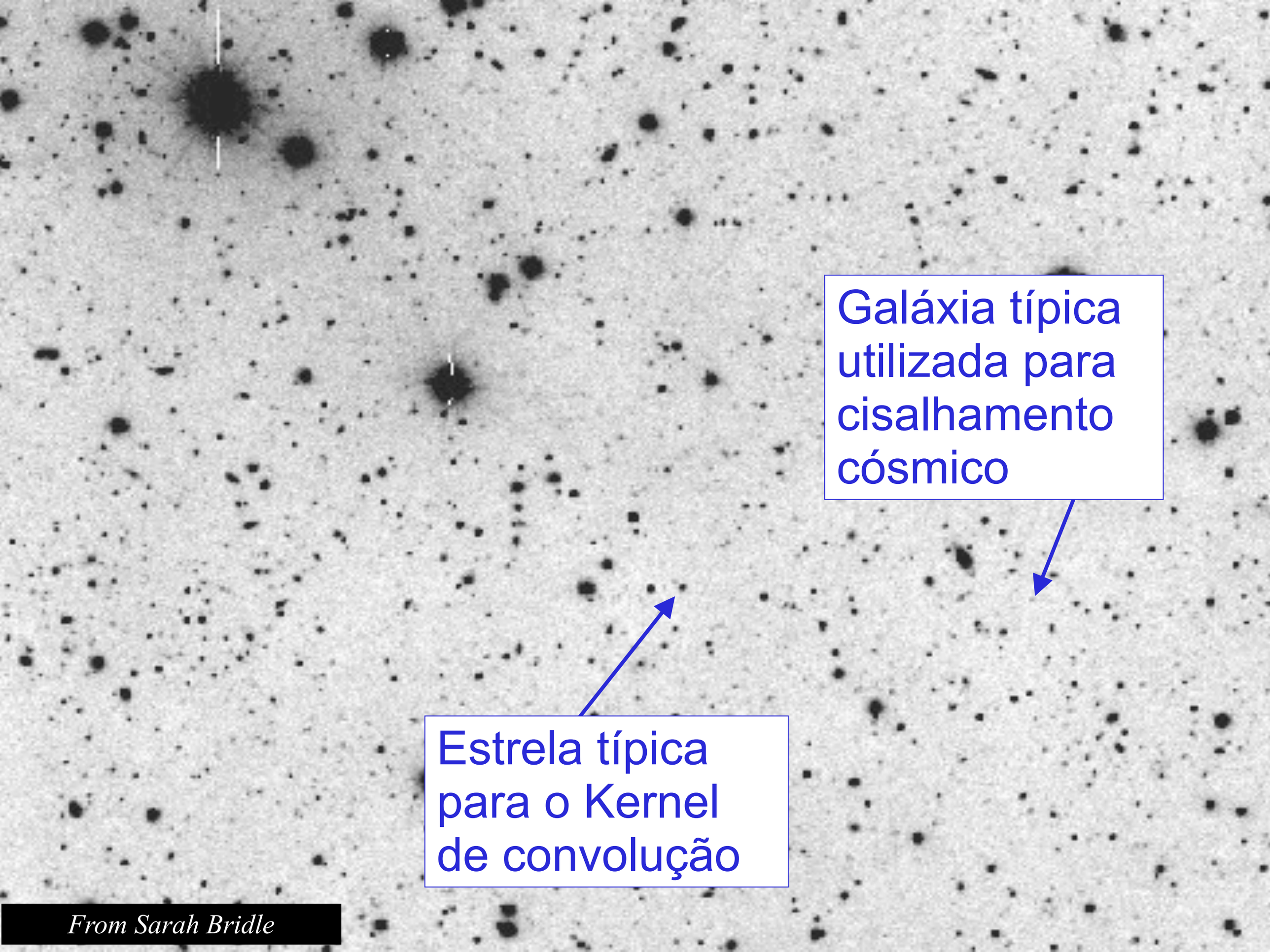
Sarah Bridle

- Modelar as distorções da PSF (muitas fontes)
  - medir um grande número de estrelas no campo



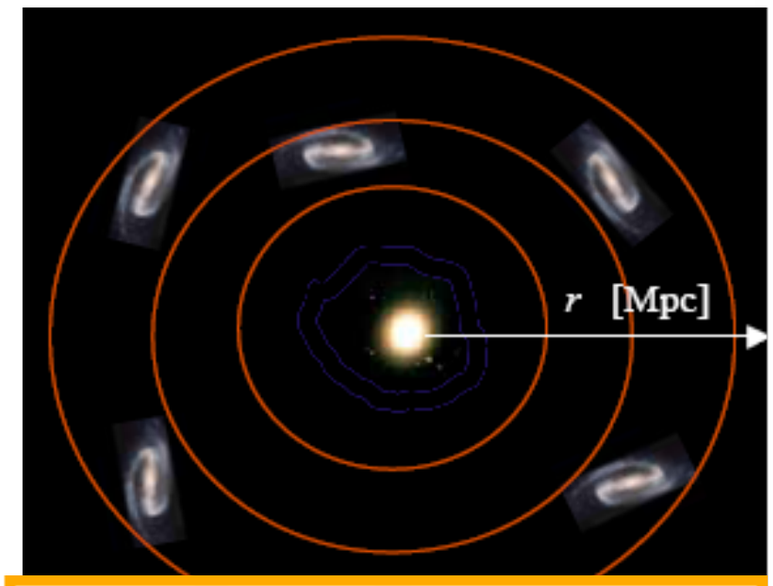
CFHTLS Deep 1
Gavazzi, Soucail 2006

- Dificuldades: estrelas saturadas, eficiência de transferência de carga, halos, acompanhamento…


Galáxia típica utilizada para cisalhamento cósmico
Estrela típica para o Kernel de convolução
From Sarah Bridle

Reconstrução de massa em aglomerados

- Medir cisalhamento tangencial pra obter $\Delta\Sigma$



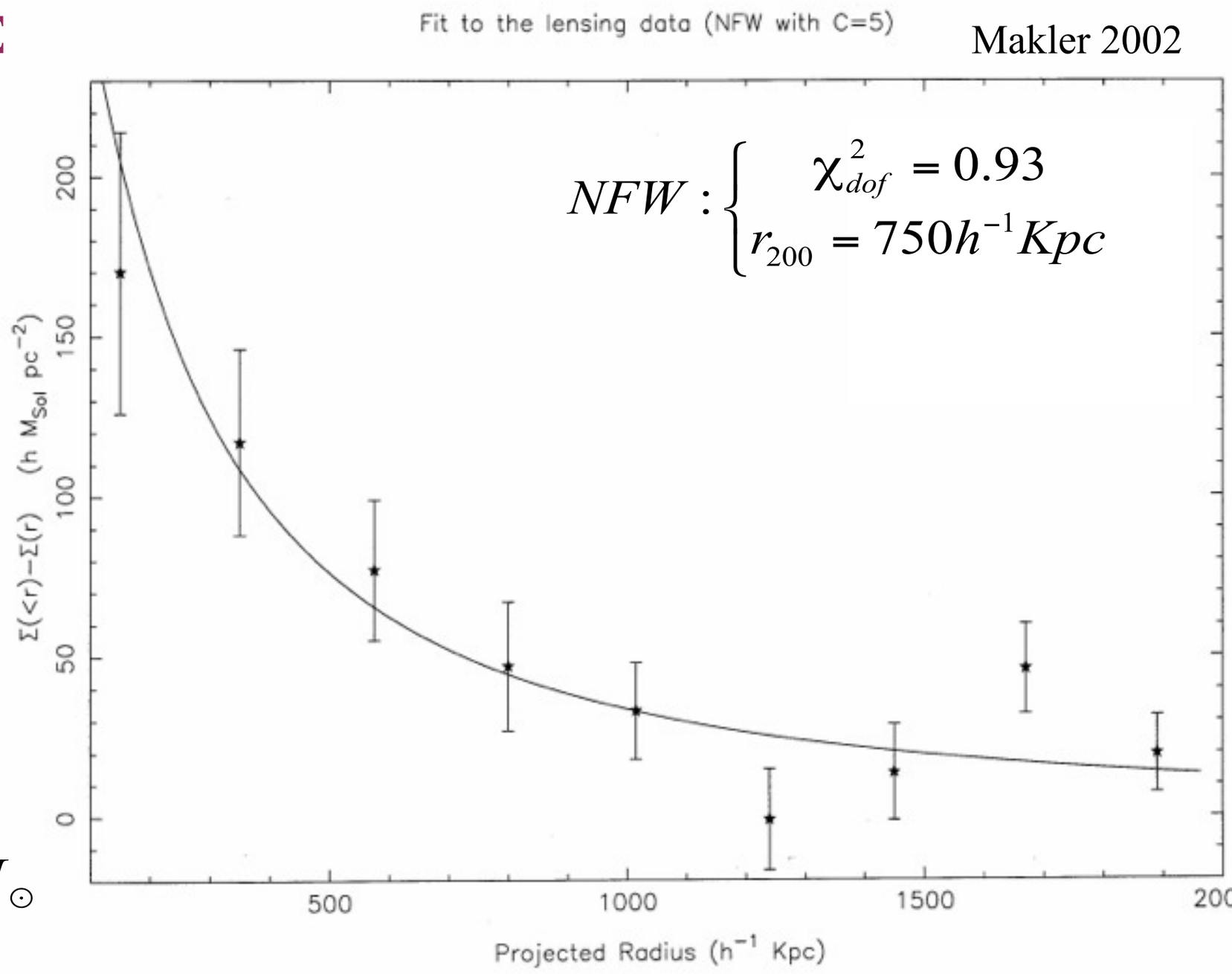
$$\Delta\Sigma(r) \equiv \overline{\Sigma}(<r) - \overline{\Sigma}(r) = \Sigma_{crit} \times \gamma_t(r)$$

$$\Sigma_{crit} = \frac{c^2}{4\pi G}\frac{D_{OS}}{D_{OL}D_{LS}}$$

- Massas:

$$\bar{M}_{NFW} = (1.0 \pm 0.2)10^{14} h^{-1} M_{\odot}$$

$$\frac{\Delta M_{200}}{M_{200}} \simeq 2.5\%$$



42 aglomerados (RASS/SDSS), Sheldon, et al., ApJ 554, 88 (2001)

Reconstrução da Massa

Potencial de lente

$$\Psi\left(\vec{\theta}\right) = \frac{1}{\pi}\int d^2\theta' \kappa\left(\vec{\theta'}\right) \ln\left|\left(\vec{\theta} - \vec{\theta'}\right)\right|$$

Cisalhamento:

$$\gamma_1(\vec{\theta}) = \frac{1}{2}(\Psi_{11} - \Psi_{22})$$

$$\gamma_2(\vec{\theta}) = \Psi_{12} = \Psi_{21}$$

$$\Gamma := \gamma_1 + i\gamma_2 = \left(\frac{\partial_1^2 - \partial_2^2}{2} + i\partial_1\partial_2\right)\Psi$$

$$\Gamma = \frac{1}{\pi}\left(\frac{\partial_1^2 - \partial_2^2}{2} + i\partial_1\partial_2\right)\int d^2\theta' \kappa\left(\vec{\theta'}\right) \ln\left|\left(\vec{\theta} - \vec{\theta'}\right)\right|$$

Reconstrução da Massa

Convolução da convergência

$$\begin{aligned}\Gamma(\vec{\theta}) &= \frac{1}{\pi}\left(\frac{\partial_1^2-\partial_2^2}{2}+i\partial_1\partial_2\right)\int \mathrm{d}^2\theta'\kappa(\vec{\theta'})\ln|\vec{\theta}-\vec{\theta'}| \\ &= \frac{1}{\pi}\int \mathrm{d}^2\theta'\kappa(\vec{\theta'})D(\vec{\theta}-\vec{\theta'}).\end{aligned}$$

Kernel

$$D(\vec{\theta}) \equiv \left(\frac{\partial_1^2-\partial_2^2}{2}+i\partial_1\partial_2\right)\ln|\vec{\theta}| = \frac{-1}{(\theta_1-i\theta_2)^2}.$$

Espaço de Fourier

$$D(\vec{\ell}) \equiv \int \mathrm{d}^2\theta D(\vec{\theta})e^{i\vec{\theta}\cdot\vec{\ell}} = \pi\frac{\ell_1^2-\ell_2^2+2i\ell_1\ell_2}{|\vec{\ell}|^2}.$$

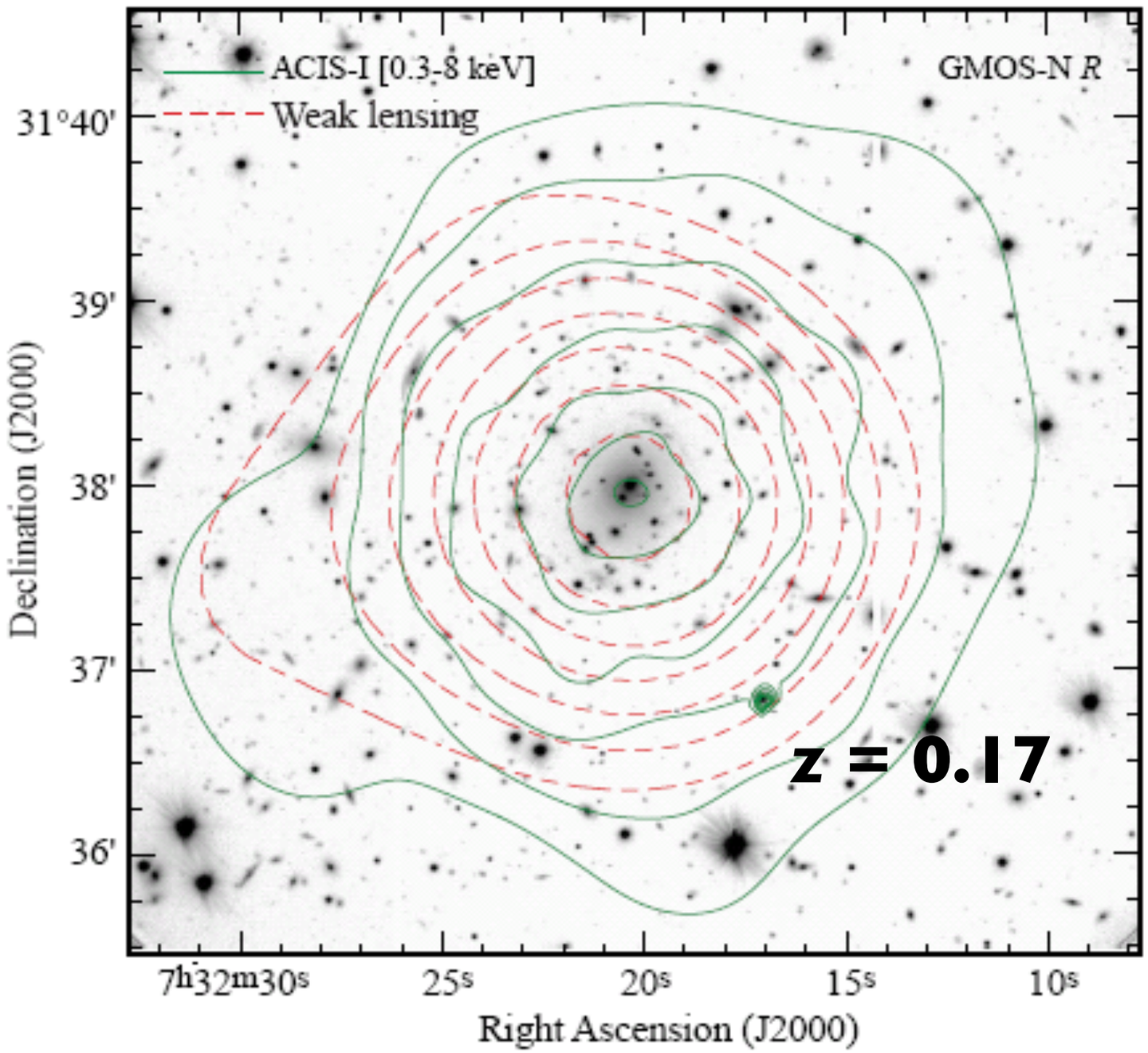
Note que $D(\vec{\ell})D^*(\vec{\ell}) = \pi^2$ Como $\Gamma(\vec{\ell}) = D(\vec{\ell})\kappa(\vec{\ell})/\pi$

temos que $\kappa(\vec{\ell}) = D^*(\vec{\ell})\Gamma(\vec{\ell})/\pi$

$$\kappa(\vec{\theta}) = \kappa_0 + \frac{1}{\pi}\int \mathrm{d}^2\theta' D^*(\vec{\theta}-\vec{\theta'})\Gamma(\vec{\theta'}).$$

Reconstrução de massa em Aglomerados

E. S. Cypriano, et al., astro-ph/0504036



Distribuição de massa

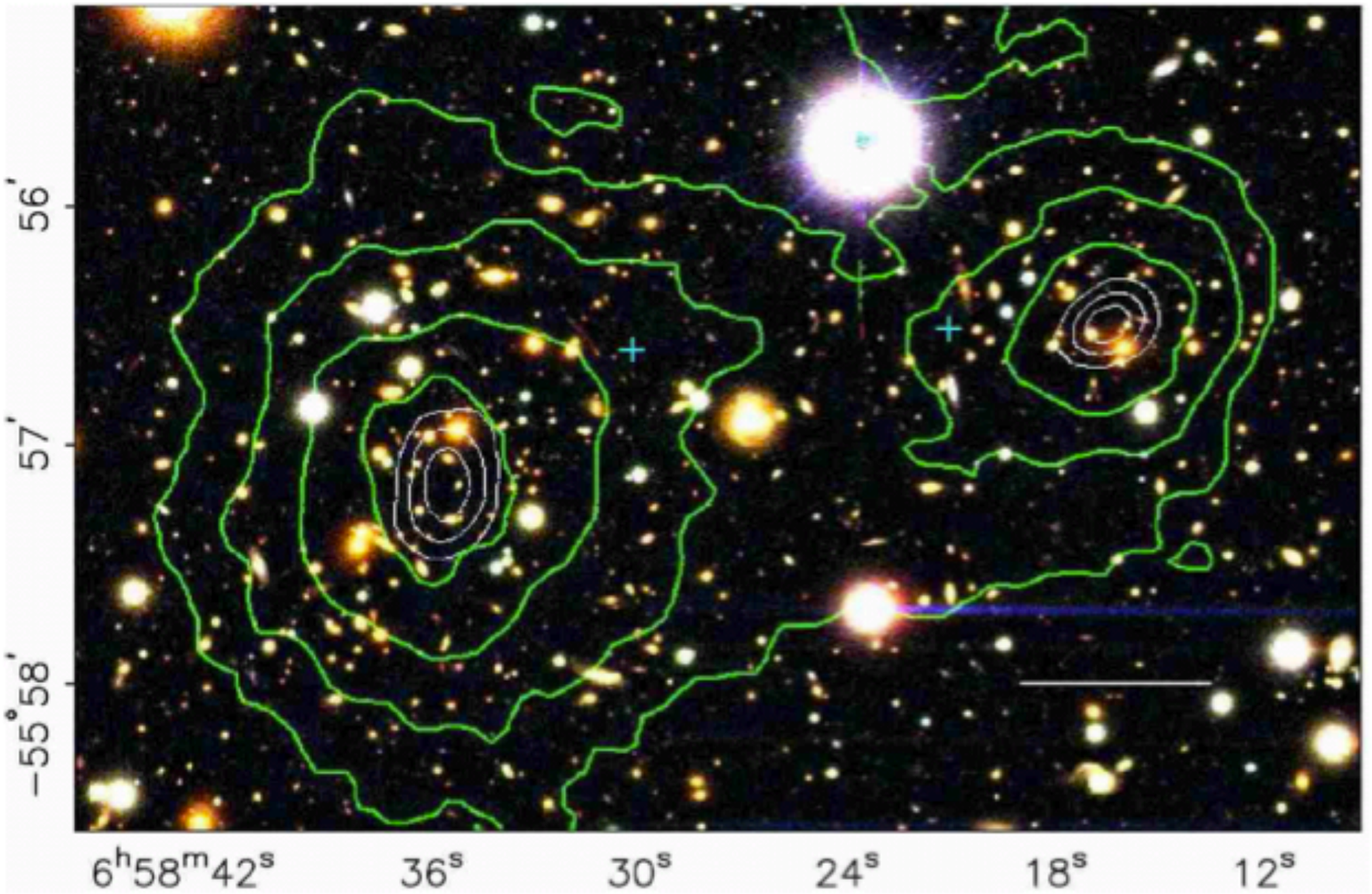
- Lentes fracas
- Emissão raios-x
- Dispersão de velocidades

concordam em 20%
(para aglomerados relaxados)

Matéria escura domina!

Evidência "direta"

- Aglomerado da bala (1E0657-558)

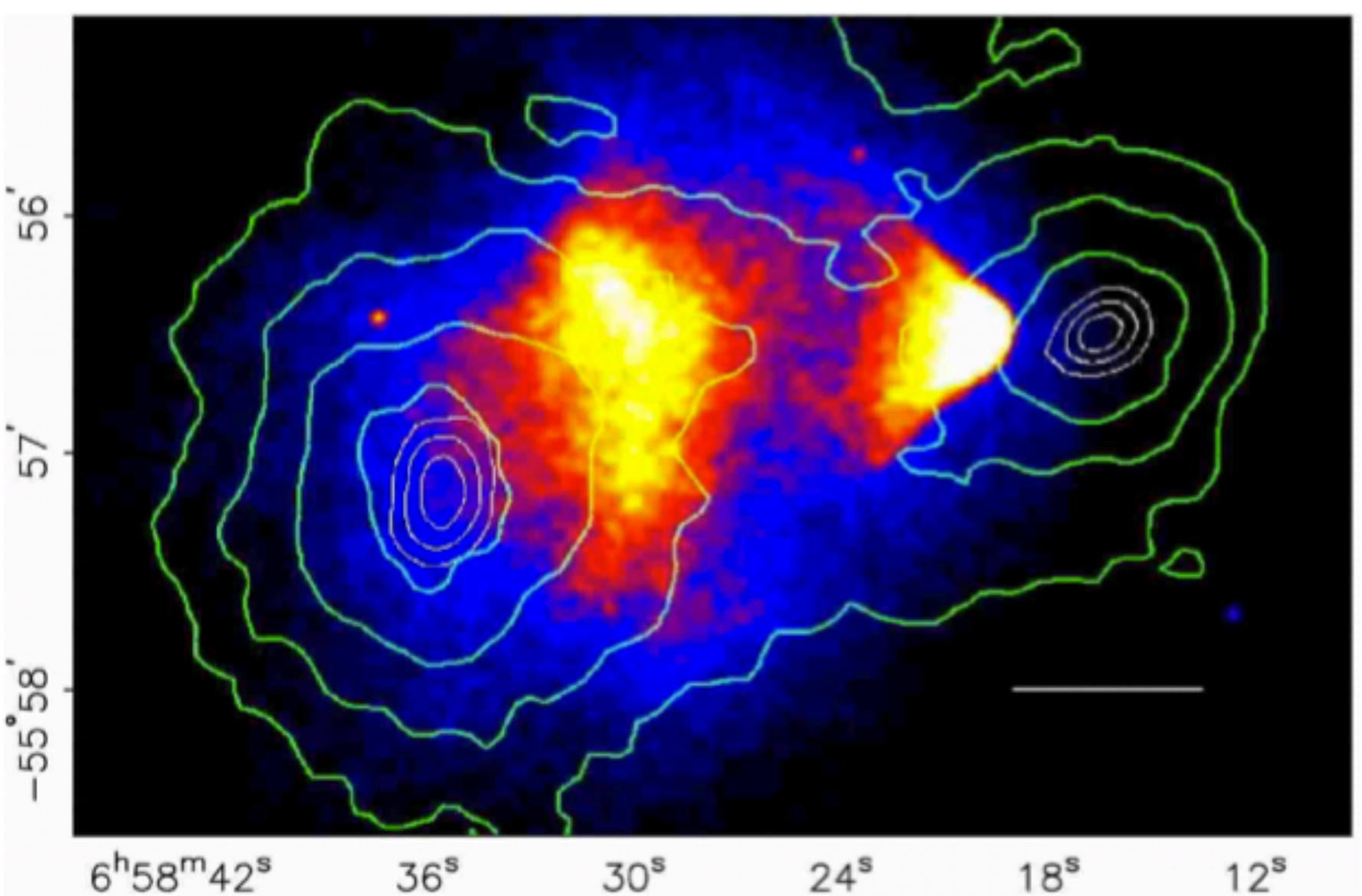


astro-ph/0608407

Reconstrução da massa pelo efeito fraco de lente gravitacional

Evidência "direta"

- Distribuição do gás



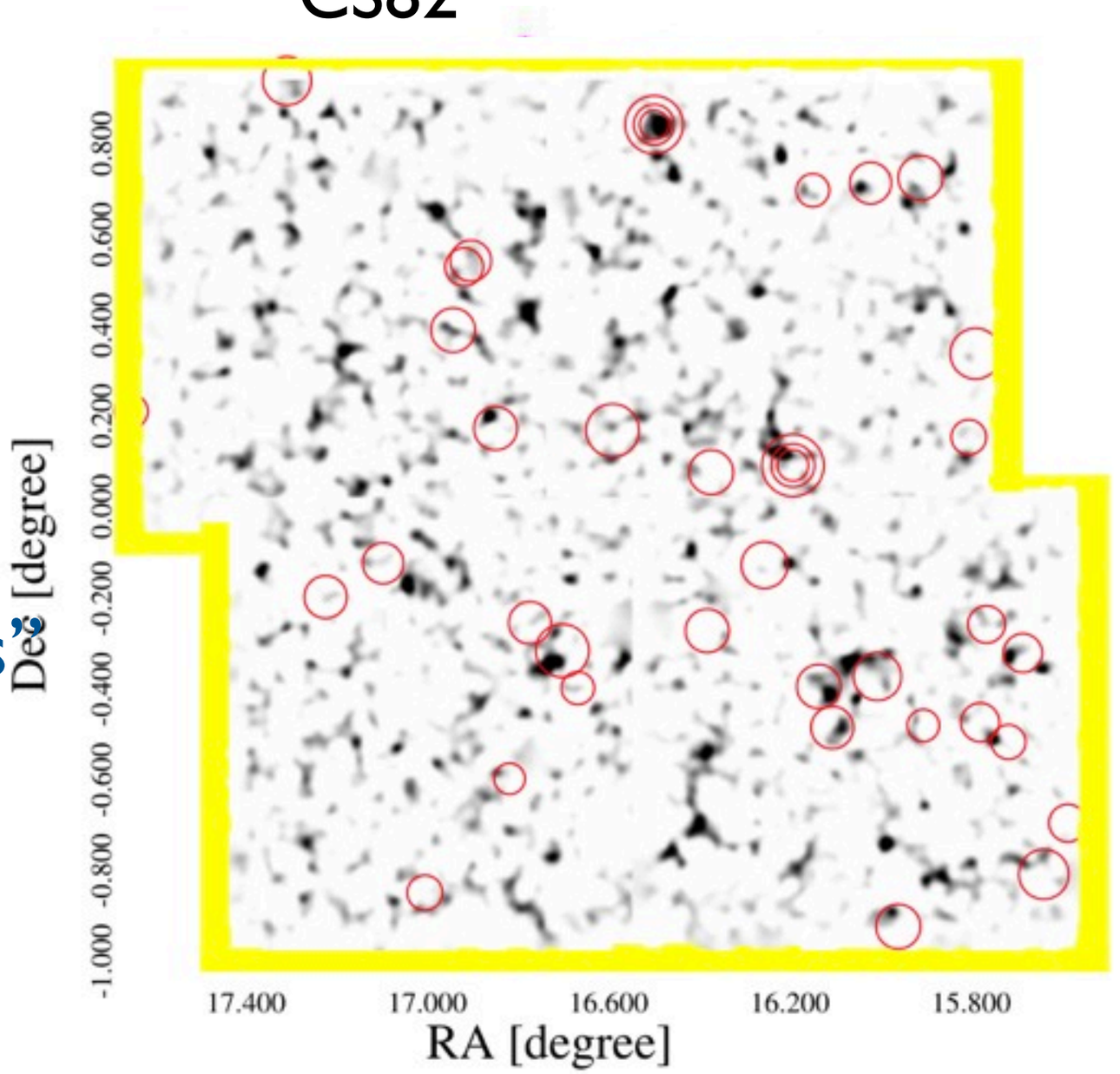
astro-ph/0608407

Desvio de 8σ nos centros de massa!

Convergence Maps

- CS82
  - *i*' seeing: 0.65"
  - Area: 173 deg^2
  - Maior mapa contíguo
- Picos →aglomerados?
  - Arcos em "picos escuros"
  - Correlação com outros catálogos/comprimentos de onda
- Estatística de picos

CS82



Huan Yuan Shen, et al. 2014
arXiv:1311.1319

www.mkaoc.org/press-room

MKAOC Mauna Kea Astronomy Outreach Committee

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Press Room

MKAOC

http://pipes.yahoo.com/pipes/pipe.info?_id=57c480a29577090254241749081379 78

[Extreme Volcanism: Image Captures one of the Brightest Volcanoes Ever Seen in the Solar System]

Aug 1, 2014 **| Gemini Observatory**

read more

[Next-Generation Thirty Meter Telescope Begins Construction in Hawaii]

Jul 29, 2014 **| Thirty Meter Telescope**

[PAES/Imiloa, Hilo, HI] The second annual Pacific Astronomy and Engineering Summit (PAES), sponsored by the Thirty Meter Telescope (TMT) and hosted by the Imiloa Astronomy Center, will gather high school students and educators from the TMT partner countries: Japan, China, India, Canada and the United States (Hawaii Island). PAES Students at Sunset on Mauna Kea read more

[Large number of Dark Matter peaks found using Gravitational Lensing]

Jul 17, 2014 **| Canada France Hawaii Telescope**

A number of studies have shown that Dark Matter is the principal mass component of the Universe making up about 80% of the mass budget. The most direct technique to reveal the Dark Matter distribution is by using the gravitational lensing technique. Indeed, following Einstein's theory of Gravitation, we know that a mass concentration will deform locally the Space-Time and the observed shapes of distant galaxies seen through the such concentration will be deflected and distorted. By measuring the exact shapes of millions of these distant galaxies we can then map accurately the mass distribution in the Universe, and identify the mass peaks tracing mass concentration along their line of sight. Importantly, the number of mass peaks as a function of the mass peak significance encodes important information on the cosmological world model. In particular this distribution is sensitive to the nature of Gravitational force at large scales as well as the geometry of the Universe. Measuring mass peaks is thus one of the most attractive way to probe the relative importance and nature of Dark Matter and Dark Energy, measure the evolution the Universe and predict its fate. In a new publication of the Monthly Notice of Royal Astronomical Society, an international team, comprising researchers from Swiss, France, Brazil, Canada, and Germany present the first detailed analysis of the weak lensing peaks. This work is considered as a milestone, given the possible importance of the weak lensing peaks for cosmology. Because mass peaks are identified in two-dimensional dark matter maps directly, they can provide constraints that are free from potential selection effects and biases involved in identifying and measuring the masses of galaxy clusters. In fact a small fraction of the max peaks are just mass concentration excess along the line of sight, and not genuine massive clusters. To detect the weak lensing mass peaks, the research team used the Canada-France-Hawaii Telescope Stripe 82 Survey (CS82 in short), still one of the largest weak lensing survey yet. The Survey covers ~170 square degrees of the Stripe 82 of the Sloan Digital Sky Survey (SDSS), an equatorial region of the South Galactic Cap that has been extensively studied by the SDSS project. With the precise shape measurement for more than four million faint distant galaxies, a dark matter mass map was generated. Huan Yuan Shan, the lead author of this publication explains that: "By studying the mass peaks in the map, we found that the abundance of mass peaks detected in CS82 is consistent with predictions from a ?CDM cosmological model. This result confirms that the dark matter distribution from weak lensing measurement can be used as a cosmological probe". For additional details and figures, please see http://cfht.hawaii.edu/en/news/MassPeaks/

[Science Results - Umbrella Galaxy's Merger Models the Cosmic Food Chain]

Jul 1, 2014 **| Subaru Telescope**

Scientists have used the Subaru Telescope and the W.M. Keck Observatory to study the Umbrella Galaxy (NGC 4651) and to accurately model how it is swallowing a smaller galaxy.

[Science Results - Jupiter's Moons Remain Slightly Illuminated, Even in Eclipse]

Jun 18, 2014 **| Subaru Telescope**

Astronomers have found that Jupiter's Galilean satellites remain slightly bright even when in the Jovian shadow

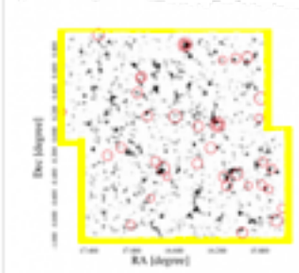
Jul 17, 2014

[Fingerprinting the formation of giant planets]

Category:Press Release

Canada France Hawaii Telescope

A team of Brazilian and American astronomers used CFHT observations of the system 16 Cygni to discover evidence of how giant planets like Jupiter form. One of the main models to form giant planets is called "core accretion". In this scenario, a rocky core forms first by aggregation of solid particles until it reaches a few Earth masses when it becomes massive enough to accrete a gaseous envelope. For the first time, astronomers have detected evidence



Jul 17, 2014

[Large number of Dark Matter peaks found using Gravitational Lensing]

Category:Press Release

Canada France Hawaii Telescope

A number of studies have shown that Dark Matter is the principal mass component of the Universe making up about 80% of the mass budget. The most direct technique to reveal the Dark Matter distribution is by using the gravitational lensing technique. Indeed, following Einstein's theory of Gravitation, we know that a mass concentration will deform locally the Space-Time and the observed shapes of distant galaxies seen through the such concentration will be deflected and distorted. By measuring the exact shapes of millions of these distant galaxies we can then map accurately the mass distribution in the Universe, and identify the mass peaks tracing mass concentration along their line of sight. Importantly, the number of mass peaks as a function of the mass peak significance encodes important information on the cosmological world model. In particular this distribution is sensitive to the nature of Gravitational force at large scales as well as the geometry of the Universe. Measuring mass peaks is thus one of the most attractive way to probe the relative importance and nature of Dark Matter and Dark Energy, measure the evolution the Universe and predict its fate. In a new publication of the Monthly Notice of Royal Astronomical Society, an international team, comprising researchers from

SBF
SOCIEDADE BRASILEIRA DE FÍSICA

Relatório
A Física e o desenvolvimento nacional

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Novo mapeamento da matéria escura

Destaque em Física, semana de 31 de julho de 2014

A matéria escura é um dos grandes mistérios da física moderna. Existem diversos modelos para explicar sua existência, mas o fato de que sua única manifestação detectável até agora é a força gravitacional que ela exerce sobre grandes objetos, como galáxias, dificulta o esclarecimento. E o que é mais chocante: ela responde por cerca de 80% do inventário total de matéria existente no Universo.



Agora, um grupo internacional de pesquisadores com importante participação brasileira realizou um mapeamento detalhado da presença de matéria escura numa faixa do céu com 124 graus quadrados de área. Para tanto, a equipe usou dados colhidos com o Telescópio Canadá-França-Havaí e extrapolou a presença de matéria escura a partir da observação de lentes gravitacionais – efeito previsto pela teoria da relatividade geral de Albert Einstein em que raios de luz são curvados ao passar por objetos massivos, sejam eles de matéria convencional ou escura.

Leia mais...

Desenrolando nanotubos de carbono



- Inscrições para a XXXVIII Reunião Anual da SAB
- Quando: 31 de agosto a 4 de setembro de 2014
- Onde: Hotel Atlântico, Búzios, RJ

POSTS RECENTES NO BLOG

[CARTA DA SAB AO MINISTRO DO MCTI, CLELIO CAMPOLINA DINIZ]
29 Jul 2014 2:28 PM • Adriana Valio

[GRUPO FAZ MAPEAMENTO DETALHADO DA MATÉRIA ESCURA DO UNIVERSO]
28 Jul 2014 5:43 PM • Adriana Valio

[RONALDO ROGÉRIO DE FREITAS MOURÃO (1935-2014)]
26 Jul 2014 5:15 PM • Adriana Valio

[MARCELLE SOARES-SANTOS RECEBE PRÊMIO ALVIN TOLLESTRUP 2014]
26 Jul 2014 2:26 PM • Adriana Valio

PRÓXIMOS EVENTOS

[Curso de Extensão Universitár... Astronomia e Astrofísica]
28 Jul 2014 • IAG - USP, São Paulo

[Composite Spectra: Reconstru...]
28 Jul 2014 • Observatório Nacional

[III Jayme Tiomno School of Co...]
04 Aug 2014 • Universidade Federal d... Janeiro, RJ

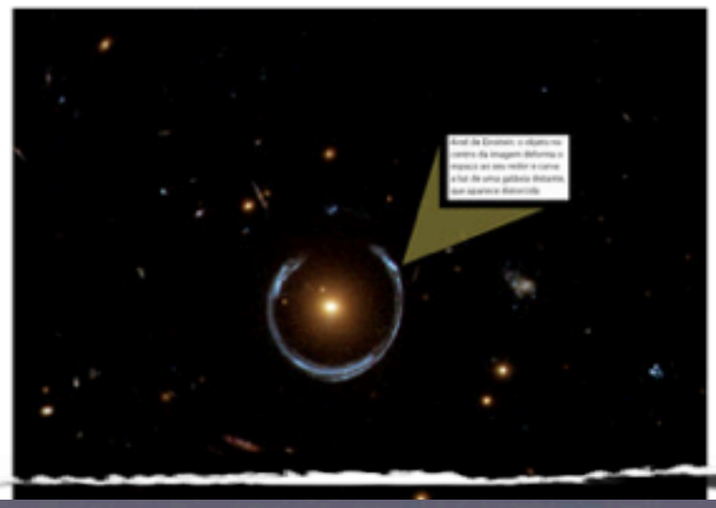
[Workshop: Oportunidades cien... instrumentos do Gemini e SOA...]
08 Aug 2014 • Delphin Hotel, Guaru...

Lupas cósmicas

Distorção gravitacional na luz de supernovas e de galáxias ajuda a investigar a distribuição de matéria e energia no Universo

REINALDO JOSÉ LOPES | ED. 223 | SETEMBRO 2014

Físicos do Rio de Janeiro, com colegas do exterior, estão dominando a arte de usar um fenômeno especial que ocorre com a luz para entender a composição e a estrutura do Universo em grandes escalas. Chamado de lente gravitacional, esse fenômeno funciona como uma espécie de lente de aumento gigantesca – uma lupa cósmica – e permite enxergar objetos celestes que muitas



Busca



ed.228 | Fevereiro 2015

Folheie a ed. 228

Como "descozinhar" o ovo

Vigilante urbano

Folheie a revista

Sumário da edição

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Suplementos Especiais
Edições Internacionais

RÁDIO

Pesquisa BRASIL

Pediatra explica quais são os riscos de uma cesariana desnecessária para a saúde dos bebês

Grupo faz mapeamento detalhado da matéria escura no Universo

Novo levantamento revelou pontos de concentração em algumas áreas inesperadas do Cosmos

Invisível, matéria escura é um dos maiores mistérios da astronomia e precisa de 'truque' para ser identificada

SALVADOR NOGUEIRA
COLABORAÇÃO PARA A FOLHA

Um grupo internacional de cientistas acaba de concluir um mapeamento detalhado da distribuição da misteriosa matéria escura no Universo.

Ninguém sabe exatamente do que ela é feita, o que se torna ainda mais constrangedor diante do fato de que ela responde por cerca de 80% de toda a matéria do Cosmos.

Os novos resultados parecem apoiar o modelo mais popular entre os cientistas, segundo o qual a matéria escura é composta por partículas que se movem a velocidades muito inferiores às da luz e que, apesar de terem massa, interagem muito fracamente com a matéria convencional.

Contudo, o estudo ainda está longe de ser capaz de discriminar de forma definitiva entre os diversos modelos cosmológicos possíveis.

"Ainda há muitas alternativas que se encaixam", disse à **Folha** Martín Makler, do Centro Brasileiro de Pesquisas Físicas (CBPF) e que participou do trabalho, publicado "Monthly Notices of the Royal Astronomical Society".

Não é trivial fazer um mapeamento de uma forma de matéria que não emite luz e que, portanto, é invisível. É preciso recorrer ao único efeito detectável produzido pela matéria escura: a gravidade que ela exerce sobre objetos visíveis. Em particular, o grupo, que tem pesquisadores da Suíça, da França, do Canadá, da Alemanha e do Brasil, explorou um fenômeno que foi primeiro previsto pela teoria da relatividade geral, de Einstein: as lentes gravitacionais.

É a ideia de que um corpo celeste mais próximo, que esteja entre nós e outro objeto mais distante, faz com que os raios de luz do objeto afastado se curvem suavemente, do mesmo jeito que a refração de uma lente convencional faz.

Como a matéria escura representa muito mais massa do que a convencional, seu efeito nas lentes gravitacionais é pronunciado. Ao detectar as distorções nos caminhos da luz, é possível estimar a quantidade de matéria escura até o objeto.

O resultado do esforço, feito com o Telescópio Canadá-França-Havaí, é um mapa bidimensional —sem profundidade— da distribuição da matéria escura, que cobre uma faixa do céu com 170 graus quadrados de área.

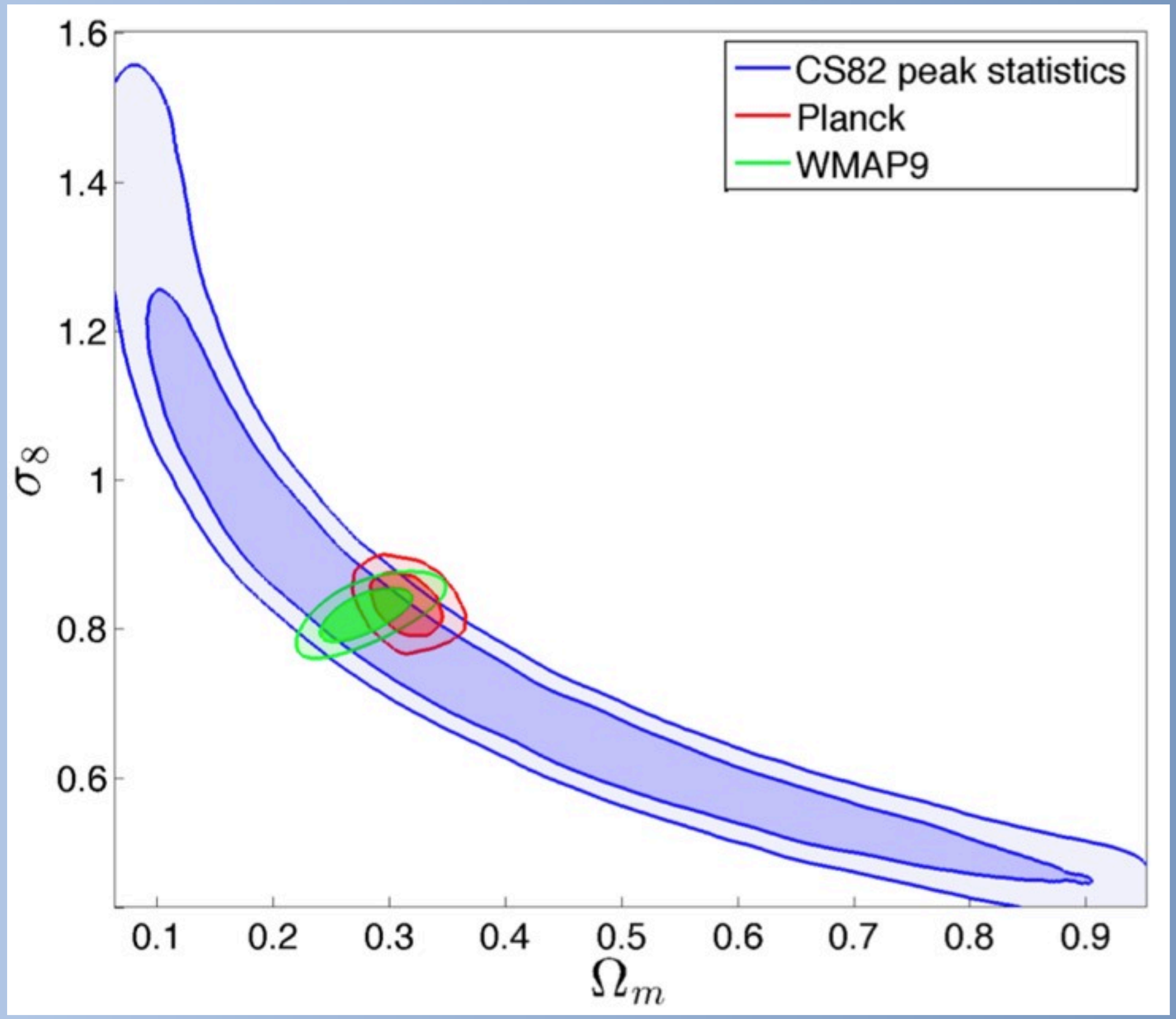
Uma das novidades importantes do estudo é a inclusão de concentrações não muito grandes de matéria escura.

O trabalho também traz novos mistérios. Os pesquisadores encontraram alguns picos que não correspondem a grupos e aglomerados de galáxias. Ou seja, os "objetos" que teriam curvado os raios de luz seriam 100% escuros, sem matéria convencional. Os cientistas agora estão concentrados em confirmar que esses picos são reais.



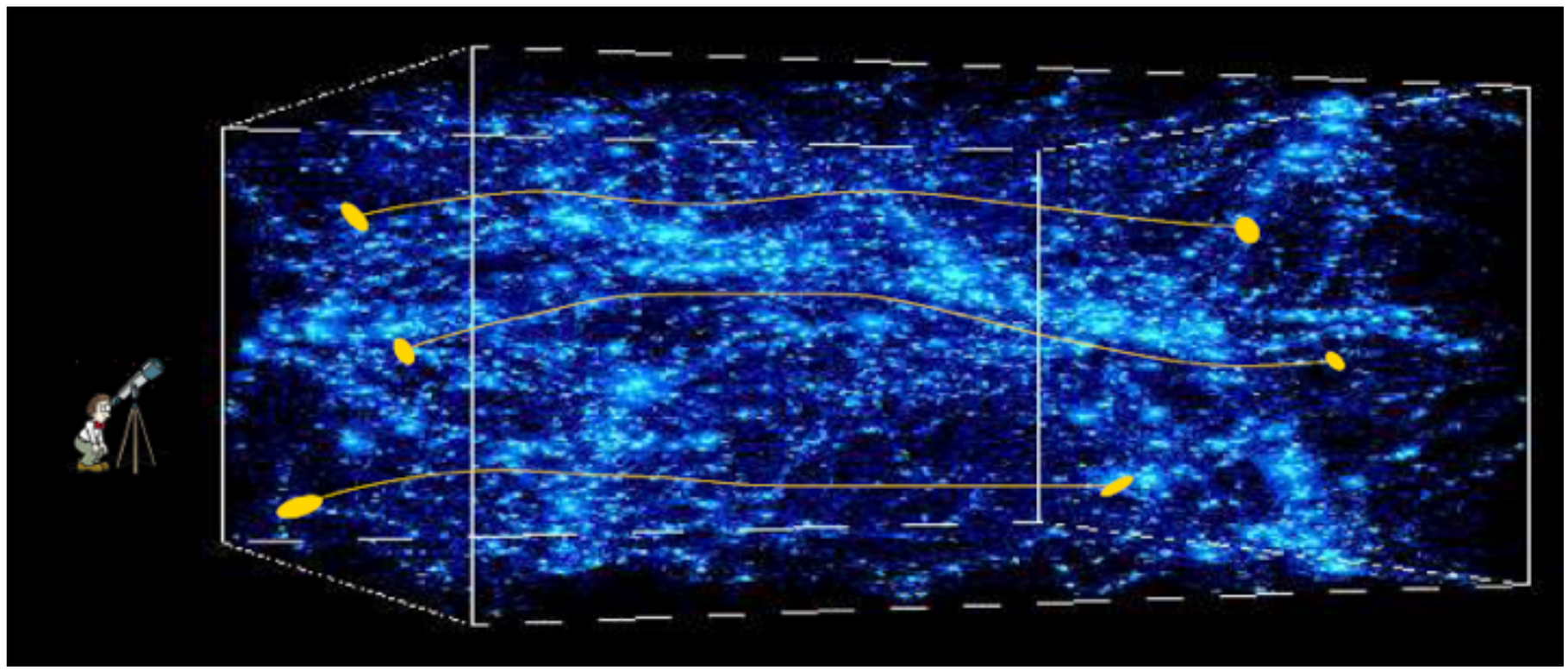
Estatística de Picos no CS82

Xiangkun Liu, et al.. 2015



Cisalhamento cósmico

- Estudo da estrutura do Universo em grandes escalas
- Tomografia



Martin Kilbinger, Institut d'Astrophysique de Paris

Lenteamento pela estrutura em grade escala: além da aproximação de lente fina

Métrica de Friedmann com perturbação escalar

$$\mathrm{d}s^2 = a^2(\tau)\left\{(1+2\frac{\varphi}{c^2})\mathrm{d}\tau^2 - (1-2\frac{\varphi}{c^2})\left[\mathrm{d}\chi^2 + r^2(\chi)(\mathrm{d}\theta^2 + \sin^2\theta\mathrm{d}\phi^2)\right]\right\}$$

Equação de geodésica

$$\frac{\mathrm{d}^2x^i}{\mathrm{d}\lambda^2} = -g^{ik}\left(\frac{\partial g_{kl}}{\partial x^m} - \frac{1}{2}\frac{\partial g_{lm}}{\partial x^k}\right)\frac{\mathrm{d}x^m}{\mathrm{d}\lambda}\frac{\mathrm{d}x^l}{\mathrm{d}\lambda}$$

Ângulo de desvio

$$\theta_\sigma(\chi) = \theta^0_\sigma - \frac{2}{c^2}\int_0^\chi \frac{\mathrm{d}\chi'}{r^2(\chi')}\int_0^{\chi'}\mathrm{d}\chi''\varphi_{,\sigma}(\vec{\theta}r(\chi''),\chi'')$$

Funções de lente

Ângulo de desvio

$$\theta_\sigma(\chi) = \theta^0_\sigma - \frac{2}{c^2}\int_0^\chi \frac{\mathrm{d}\chi'}{r^2(\chi')}\int_0^{\chi'} \mathrm{d}\chi'' \varphi_{,\sigma}(\vec{\theta} r(\chi''), \chi'')$$

Se reduz a uma integral ao longo da trajetória do fóton

$$\theta_\sigma(\chi) = \theta^0_\sigma - \frac{2}{c^2}\int_0^\chi \mathrm{d}\chi' \varphi_{,\sigma}(\vec{\theta} r(\chi'), \chi')\frac{r(\chi-\chi')}{r(\chi)r(\chi')}$$

Potencial de lente

$$\Psi = \frac{2}{c^2 r(\chi)}\int_0^\chi \mathrm{d}\chi' \varphi(\vec{\theta} r(\chi'), \chi')\frac{r(\chi-\chi')}{r(\chi')}$$

Convergência

$$\kappa(\vec{\theta}) = \frac{1}{2}\nabla^2_\theta \Psi = \frac{1}{c^2}\int_0^\chi \mathrm{d}\chi' \nabla^2_\perp \varphi(\vec{x}_\perp, \chi')\frac{r(\chi-\chi')r(\chi')}{r(\chi)}$$

Funções de lente

Usando a equação de Poisson para as perturbações

$$\nabla^2\varphi(\vec{x},\tau) = \frac{3H_0^2\Omega_m}{2a(\tau)}\delta(\vec{x},\tau)$$

A convergência fica

$$\kappa(\vec{\theta}) = \frac{3H_0^2\Omega_m}{2c^2}\int_0^{\chi_H} \mathrm{d}\chi\delta(\vec{x}_\perp,\chi)\frac{g(\chi)}{a(\chi)}$$

Onde

$$g(\chi) = r(\chi)\int_\chi^{\chi_H} \mathrm{d}\chi'\frac{r(\chi-\chi')n(\chi')}{r(\chi')}$$

Funções de lente

$$\kappa(\vec{\theta}) = \frac{3H_0^2\Omega_m}{2c^2}\int_0^{\chi_H} \mathrm{d}\chi\delta(\vec{x}_\perp,\chi)\frac{g(\chi)}{a(\chi)}$$

No espaço de Fourier

$$\kappa(\vec{\ell}) = \int \mathrm{d}^2\theta\ \kappa(\vec{\theta})e^{i\vec{\ell}\cdot\vec{\theta}}$$

temos

$$\langle\kappa(\vec{\ell})\kappa(\vec{\ell}')\rangle = (2\pi)^2\delta^{(2)}(\vec{\ell}-\vec{\ell}')P_\kappa(\ell)$$

e o espectro de potências é dado por

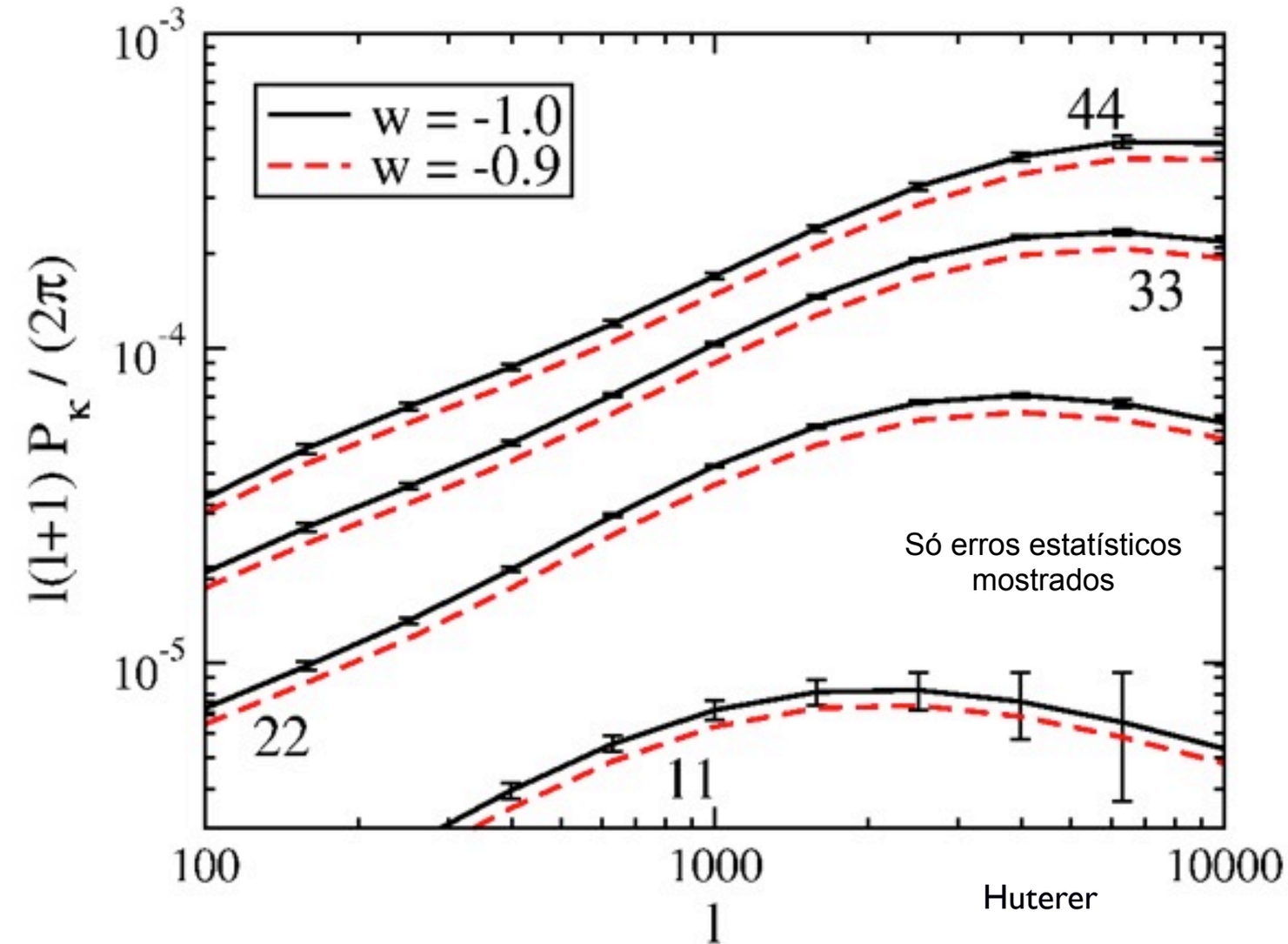
$$P_\kappa(\ell) = \frac{9H_0^4\Omega_m^2}{4c^4}\int_0^{\chi_H}\mathrm{d}\chi\frac{g^2(\chi)}{a^2(\chi)}P_\delta\left(\frac{\ell}{r(\chi)},\chi\right)$$

Cisalhamento cósmico

- Efeito fraco de lente (estatístico)
- **Sensível à energia escura (geometria + fator de crescimento)**
- **Menos sensível à física bariônica**
- Grandes separações: linear
- Exemplo: espectro de potência do cisalhamento cósmico em quatro fatias de foto z's (tomografia)

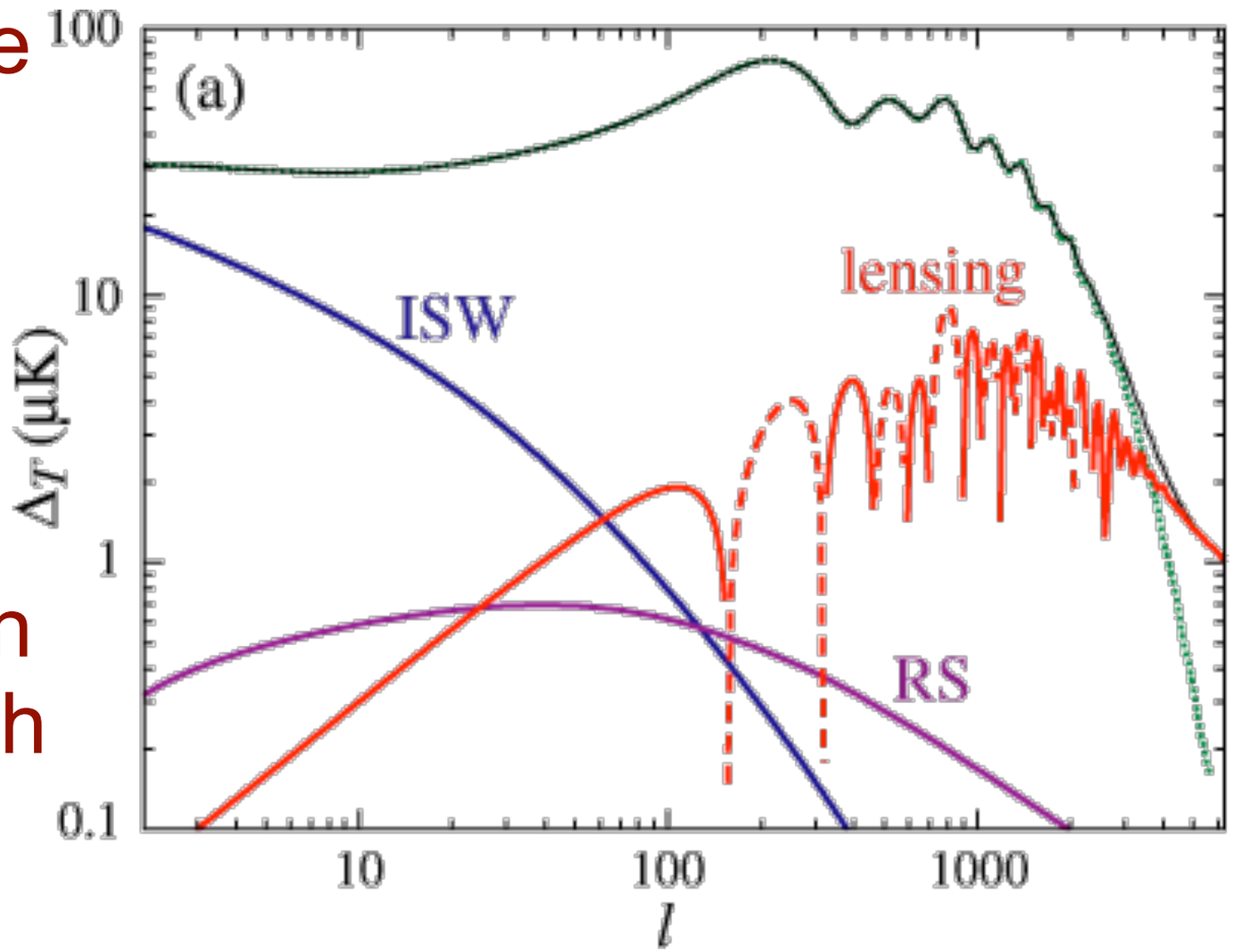
$$C_\ell^{x_a x_b} = \int dz \frac{H(z)}{D_A^2(z)} W_a(z) W_b(z) P^{s_a s_b}(k = \ell / D_A; z)$$

$$\Delta C_\ell = \sqrt{\frac{2}{(2\ell+1) f_{sky}}} \left(C_\ell + \frac{\sigma^2(\gamma_i)}{n_{eff}} \right)$$



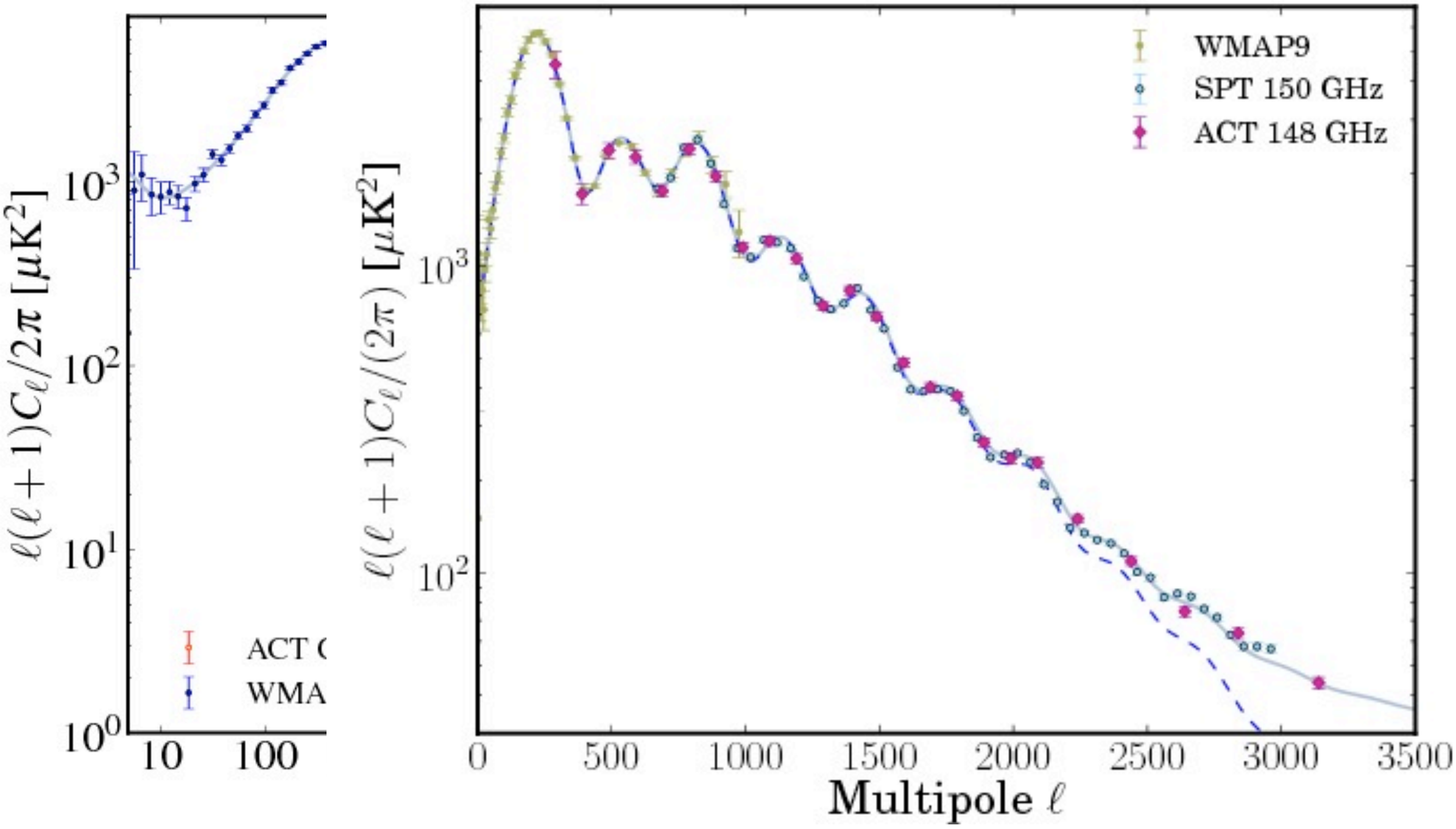
Secondary Anisotropies

- Integrated Sachs-Wolfe effect
- Gravitational Lensing
- Rees-Sciama effect
- Gravitational waves
- Scattering: reionization and Sunyaev Zel'dovich

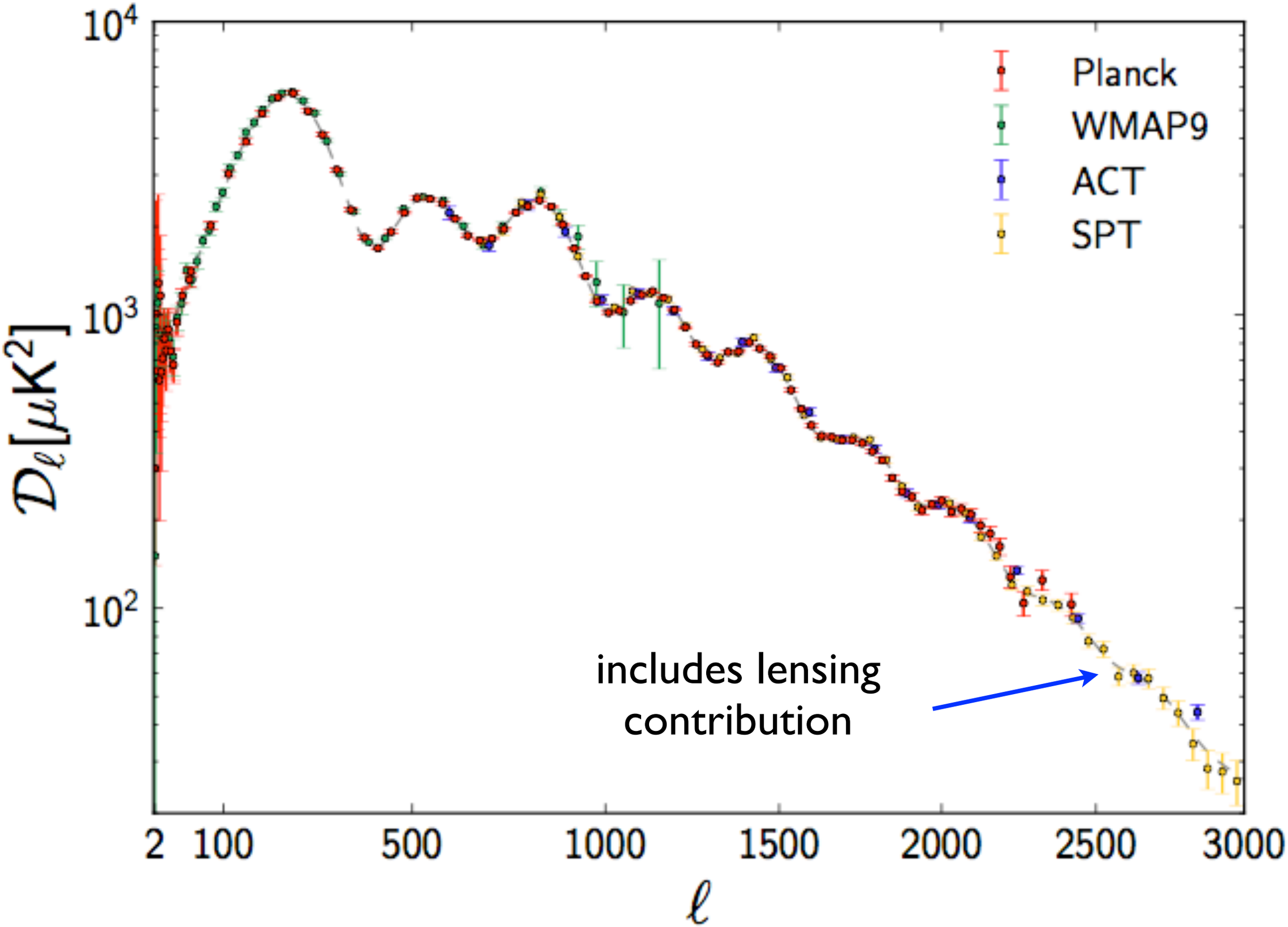


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Small scale spectrum



Power spectrum @ 2013



PHYSICAL REVIEW D
particles, fields, gravitation, and cosmology

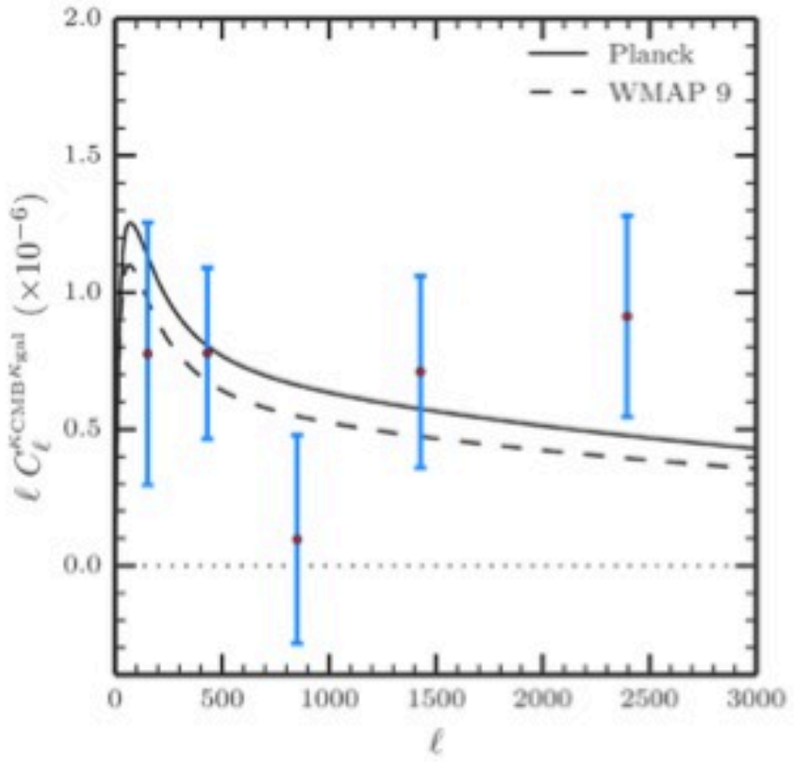
Highlights Recent Accepted Authors R

Correlation of CMB lensing with LSS lensing on CS82

EDITORS' SUGGESTION

First measurement of the cross-correlation of CMB lensing and galaxy lensing

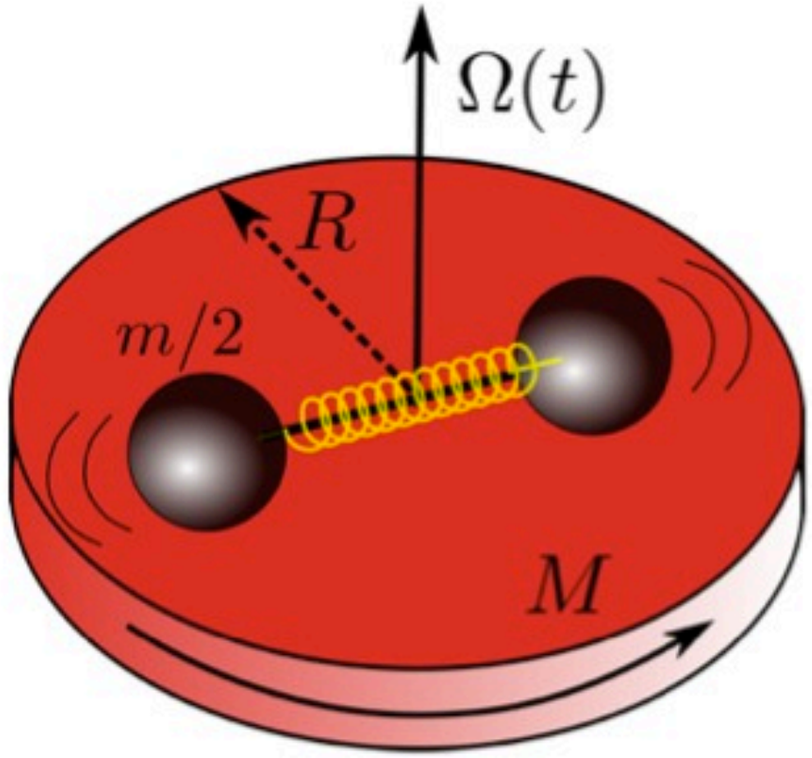
CS82 x ACT



The authors measure for the first time the cross-correlation between CMB lensing and galaxy lensing. This provides a robust test of the ΛCDM model on the largest cosmic scales, and offers powerful constraints on the evolution and nature of dark energy, the amplitude of matter

EDITORS' SUGGESTION

Spectral properties of the post-merger gravitational-wave signal from binary neutron stars



Can gravitational waves from merging neutron star binaries be used to determine characteristics of neutron stars? Extensive numerical relativity simulations reported here show that these signals can be used to set

Hand et al. 2015, Phys. Rev. D, 91, 062001

Concluding remarks

- Strong lensing has become a useful cosmological and astrophysical observable, fulfilling its promises for studying the lenses, the sources, and the large-scale geometry of the Universe
  - Unique for modified gravity and DM properties
  - Unique for inner cluster regions and inner ETG slope
  - Resolving ~ 10-100 pc @ z ~ 1
- Synergy between wide-field studies and targeted observations
- Interdisciplinary field involving from fundamental physics to data reduction, including image processing, statistics, simulations, theory and semi-analytic modeling
- CS82 is an excellent playground for SL in wide-field surveys
- Lots of excellent data to come in the near future! (DES, KiDS, J-PAS, LSST, Euclid, WFIRST...)

Concluding remarks

- These lectures: 2 cosmological observables (SNIa + CMB) + lensing phenomena
- Cosmology:
  - Flooded with data and yet more high quality data to come!
  - Interdisciplinary
  - astrophysics x fundamental physics
  - Incredibly successful model
  - Many open problems
- The world is yours, but be careful!
  - Precision cosmology is also systematics dominated cosmology
  - Need to understand astrophysics!
- Avoid confirmation bias! Do it blindly if you can
- Relax and have fun!

Thank You




BARYONIC P-ROCESSES
DENSITY PROFILES AND CONCEN-TRATION
LENS MASS DISTRIBUTI-ON
COSMOLOGIC-AL DISTANC-ES
TIME DELAYS AND-HUBBLE CO-NSTANT
DARK MATTER SELF-INTER-ACTION
DARK ENERG-Y PARAMETE-RS
STRONG LENSING
MASS CALLI-BRATION
MODIFIED GRAVITY
MASS LUMIN-OSITY RATI-OS
GRAVITATIO-NAL TELESC-OPES
HIGH REDSH-IFT UNIVER-SE
DARK MATTER MASS
BARYON - DARK - MATTER INT-ERACTION

Leitura sugerida na área de lentes gravitacionais

- Peter Schneider, Christopher S. Kochanek, Joachim Wambsganss, 33rd Advanced Saas-Fee Course on Gravitational Lensing (2003):
  - Saas-Fee Advanced Course 33 - Springer
  - https://astro.uni-bonn.de/~peter/SaasFee.html
- Ramesh Narayan and Matthias Bartelmann, Lectures on Gravitational Lensing (Proceedings of the 1995 Jerusalem Winter School)
  - http://arxiv.org/abs/astro-ph/9606001,
  - http://www.mpa-garching.mpg.de/Lenses/JeruLect.html, (recomendo a opção: http://www.mpa-garching.mpg.de/Lenses/JL_co_art.ps.gz para baixar direto)
- Schneider P., Elhers J., Falco E. E., 1992, Gravitational lenses. Springer-Verlag, Berlin
- Mollerach, S, Roulet, E, 2002. Gravitational Lensing and Microlensing, World Scientific, Singapore.
- Petters A.,O., Levine H., Wambsganss J., 2001, Singularity Theory and Gravitational Lensing. Birkhäuser, Boston

Advertisements

School on Dark Matter and Neutrino Detection

July 23 – August 3, 2018

WORKSHOP ON ANDES

August 6-8, 2018

ICTP SAIFR

unesp IFT

FAPESP ICTP

School on Dark Matter and Neutrino Detection

- Theory/overview + experimental methods
- Practical activities and labs
- Synergy with ANDES workshop
- *Support for selected attendants*

Tentative Program

- Week 1: Theory and overview

9:30-10:45	Dark Matter	Dark Matter	Dark Matter	Dark Matter	Dark Matter
10:45-11:15	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*
11:15-12:30	Neutrinos in Cosmology	Neutrinos in Cosmology	Sterile neutrinos	Nonstandard neutrinos	DM in colliders
12:30-14:00	*Lunch*	*Lunch*	*Lunch*	*Lunch*	*Lunch*
14:00-15:15	Neutrinos	Neutrinos	IFT colloquium	Neutrinos	Neutrinos
15:15-15:45	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*
15:45-17:00	DM in the galaxy	Indirect Detection	Neutrinos	Small scale problems	Small scale problems
17:00-17:45	General questions	General questions	DM at colliders	General questions	General questions
17:45-18:00	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*
18:00-19:30	Practical activities	Practical activities	Practical activities	Practical activities	Practical activities

Tentative Program

- Week 2: Detection

9:30-10:30	WIMP DM detection	WIMP DM detection	WIMP DM detection	WIMP DM detection	WIMP DM detection
10:30-11:30	Neutrino detection	Neutrino detection	Neutrino detection	Neutrino detection	Neutrino detection
11:30-11:45	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*
11:45-12:45	detection technology: CCD	detection technology: CCD	detection technology: CCD	detection technology: cryogenic	detection technology: cryogenic
12:45-14:15	*Lunch*	*Lunch*	*Lunch*	*Lunch*	*Lunch*
14:15-15:15	Coherent neutrinos	Noble liquid/gas detectors	(14:00) IFT colloquium	ANDES	Semi-conductor
15:15-15:30	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*
15:30-19:30	Labs	Labs	Labs	Labs	Labs