# Observational prospects of axion inflation:

## with Abelian and non-Abelian gauge fields

Oksana Iarygina

PASCOS 2026, Sheffield

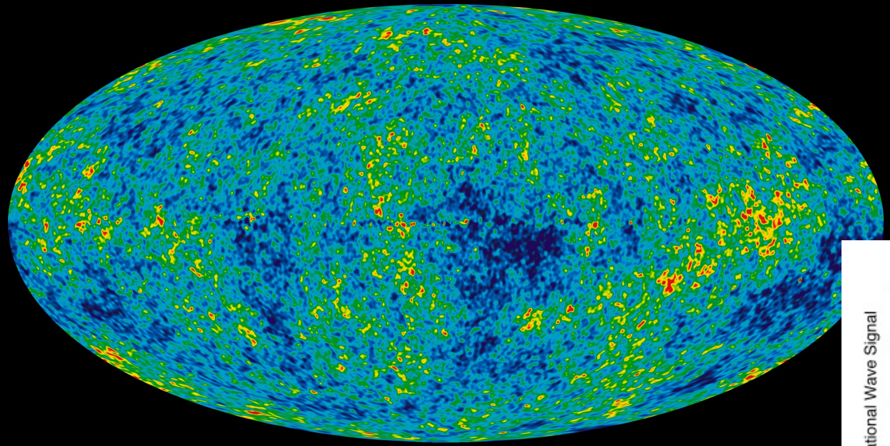
NORDITA
The Nordic Institute for Theoretical Physics

Stockholm University

Vetenskapsrådet
MARIE CURIE ACTIONS
Funded by the European Union

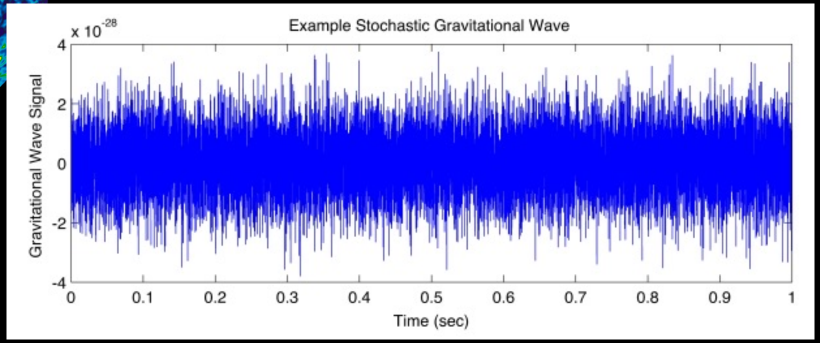
# Multi-messenger cosmology from gauge fields

Scalar perturbations



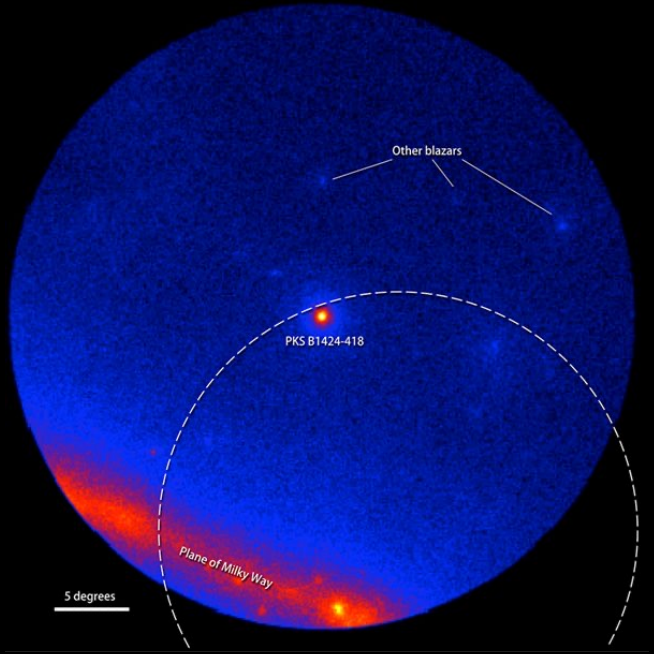
[Planck]

Graviational waves




[LIGO/VIRGO]

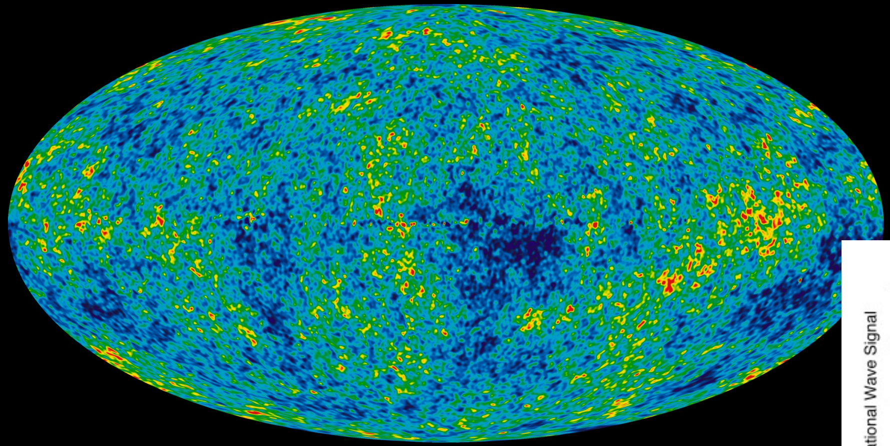
Primordial magnetic fields




[NASA/DOE/LAT Collaboration]

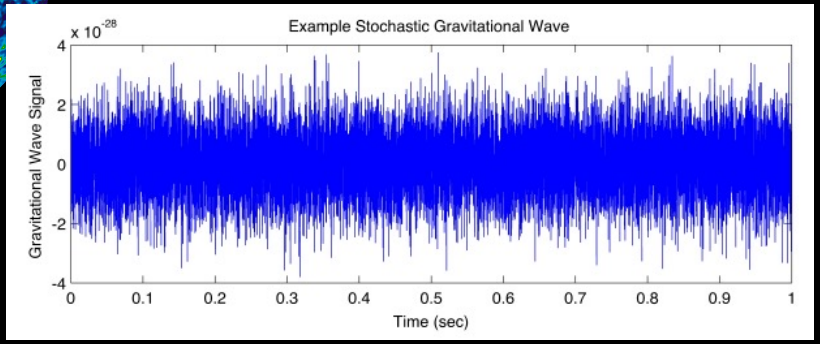
# Multi-messenger cosmology from gauge fields

## Scalar perturbations



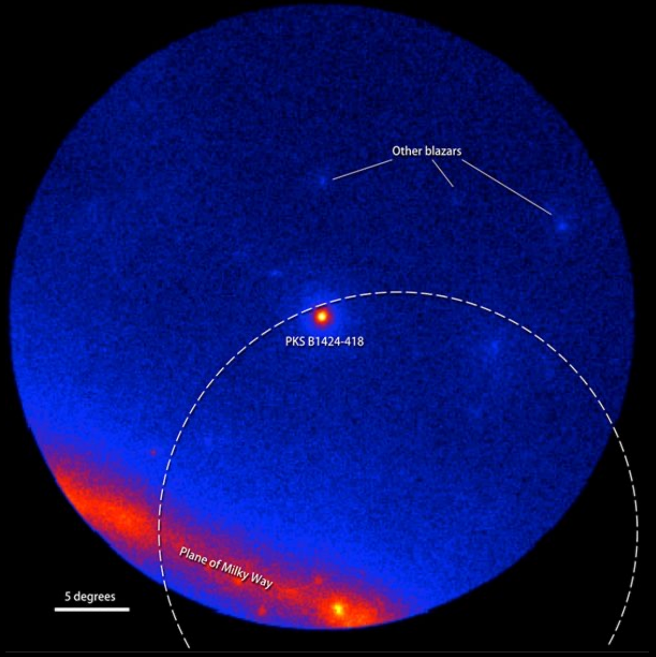
[Planck]

## Graviational waves



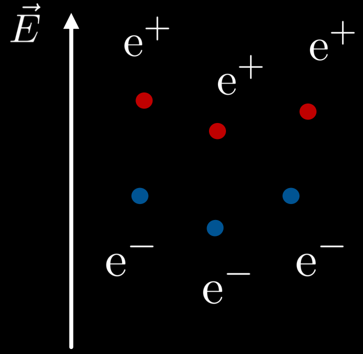

[LIGO/VIRGO]

## Primordial magnetic fields




[NASA/DOE/LAT Collaboration]

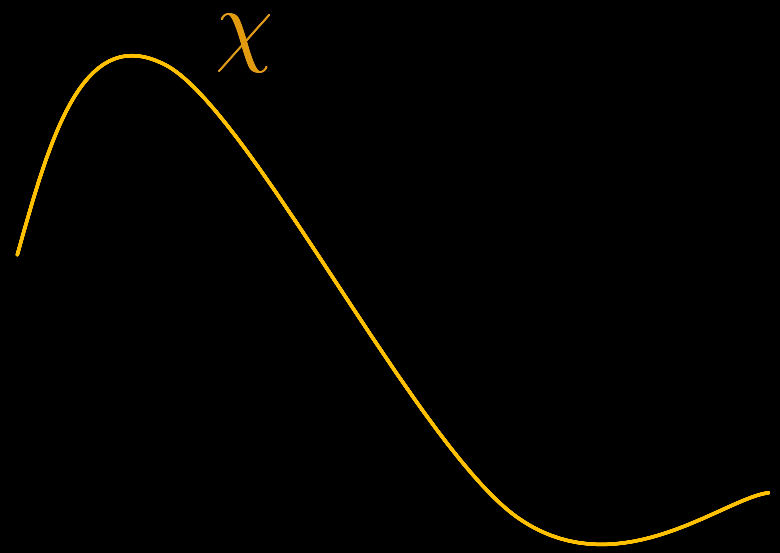
+ Schwinger effect



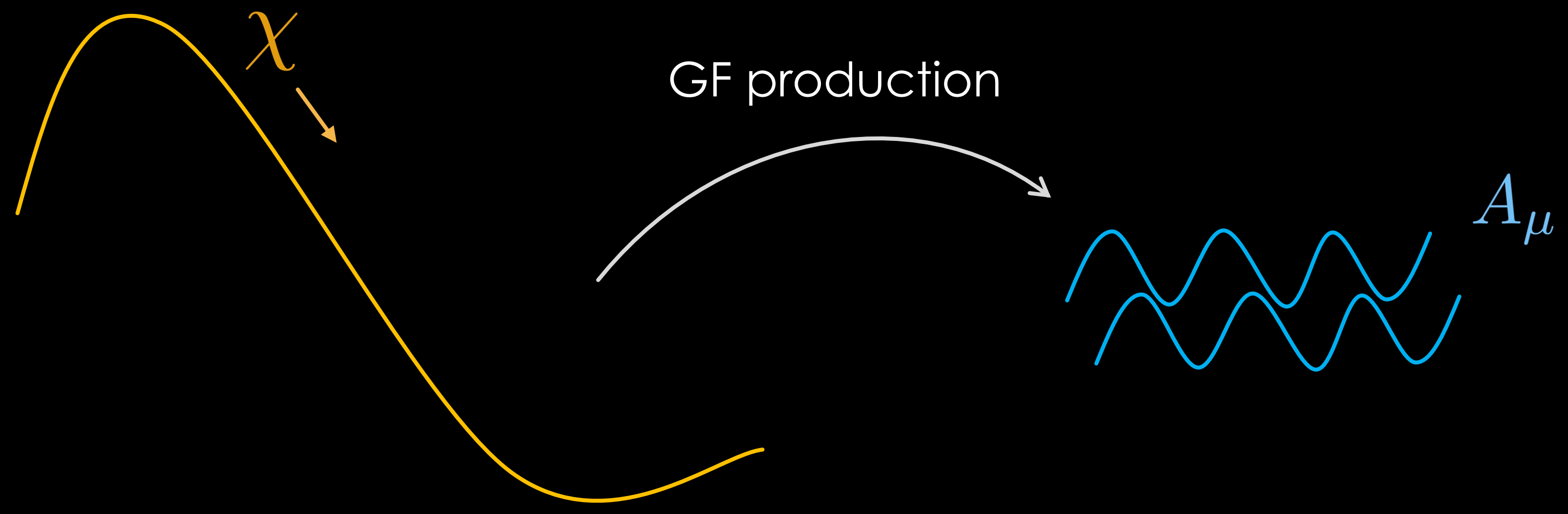
axion $\longrightarrow$ $\frac{\chi}{4f}\lambda F^a_{\mu\nu}\tilde{F}^{a\,\mu\nu}$

axion → $\frac{\chi}{4f}\lambda F^{a}_{\mu\nu}\tilde{F}^{a\,\mu\nu}$ ← gauge field

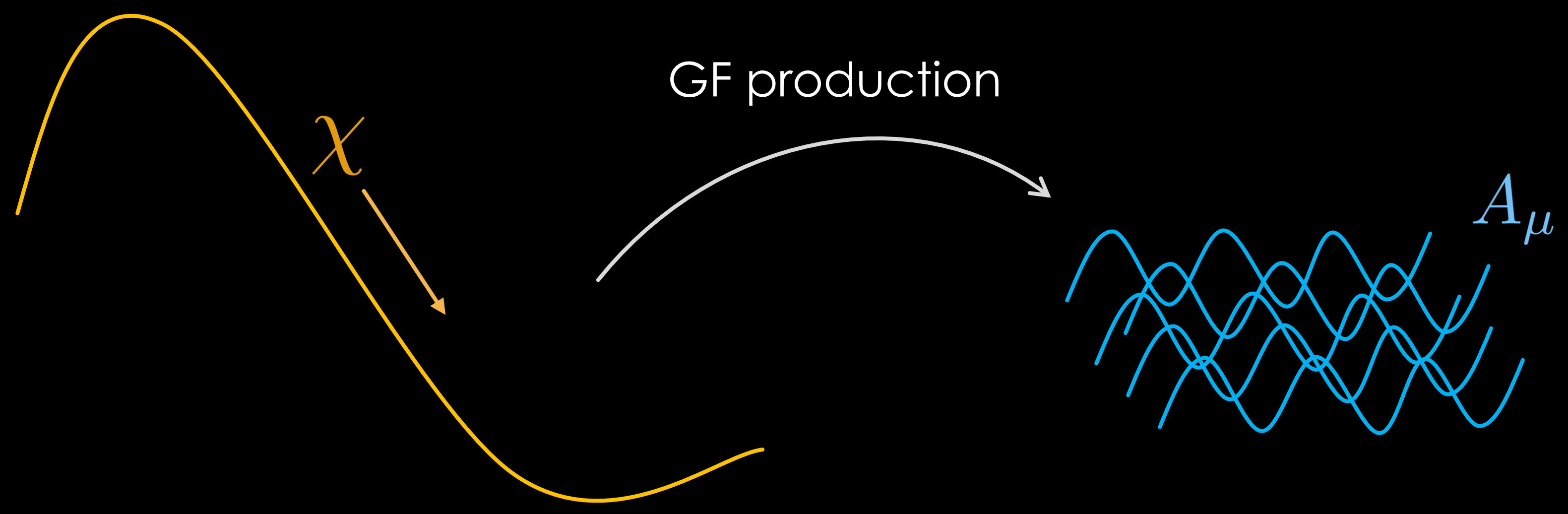
$$\frac{\chi}{4f}\lambda F^{a}_{\mu\nu}\tilde{F}^{a\,\mu\nu}$$



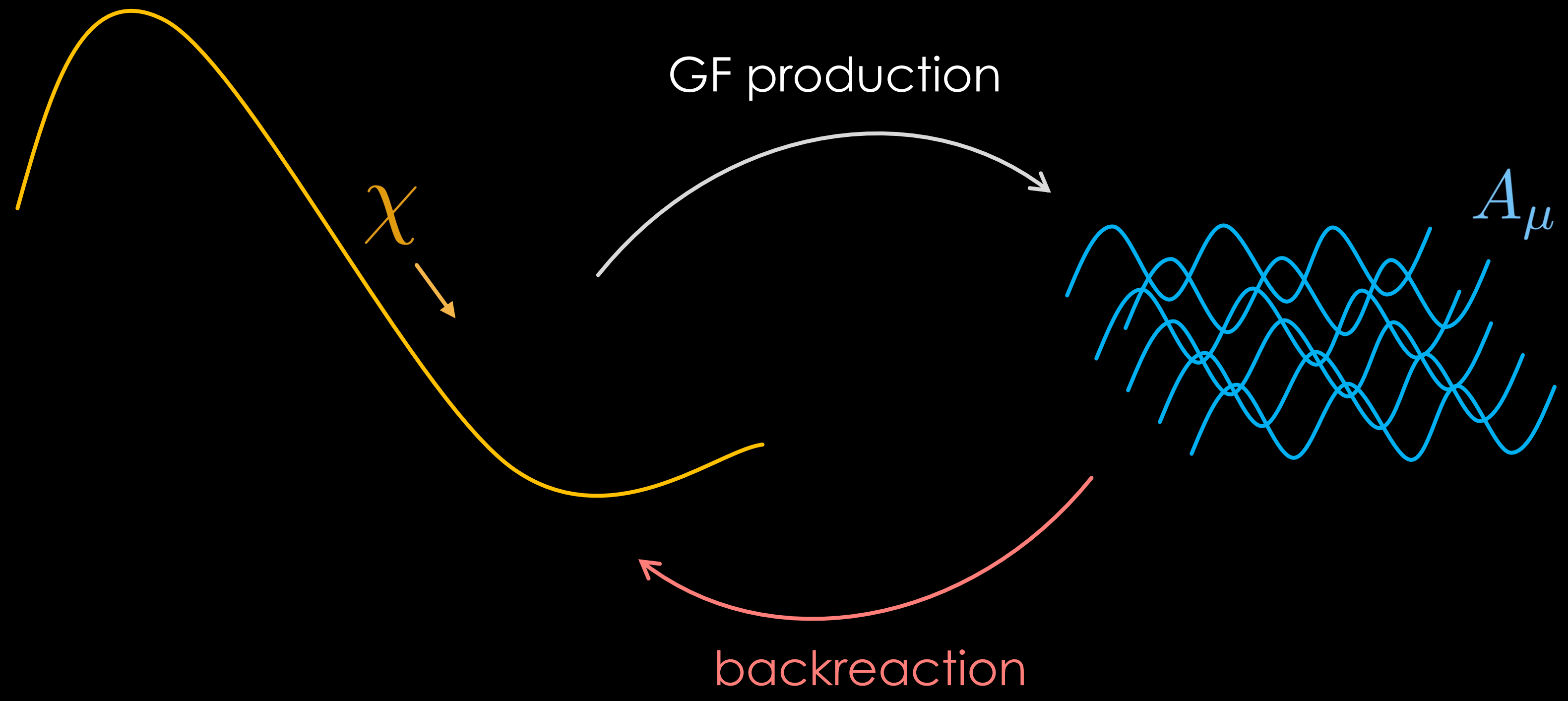
$$\frac{\chi}{4f}\lambda F^a_{\mu\nu}\tilde{F}^{a\,\mu\nu}$$



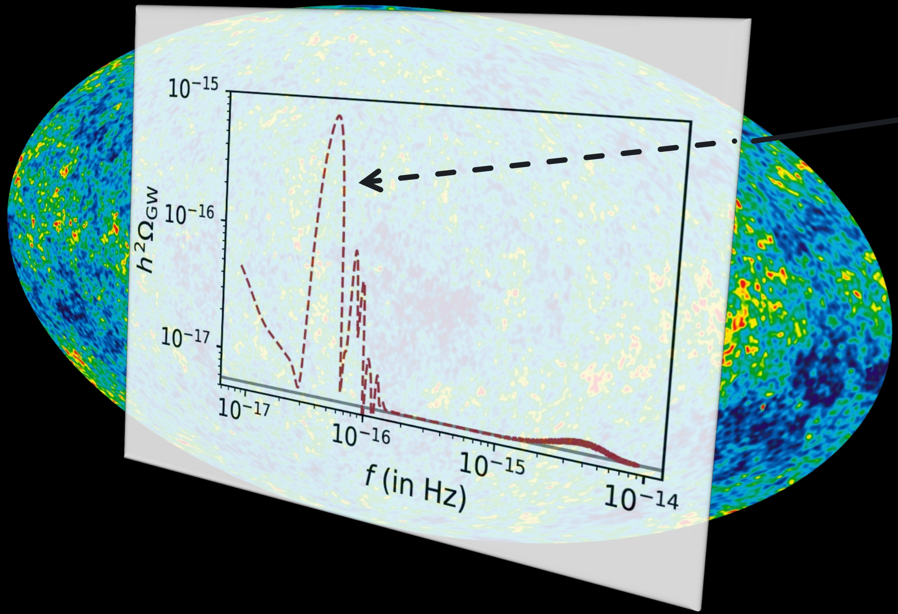
$$\frac{\chi}{4f}\lambda F^a_{\mu\nu}\tilde{F}^{a\,\mu\nu}$$



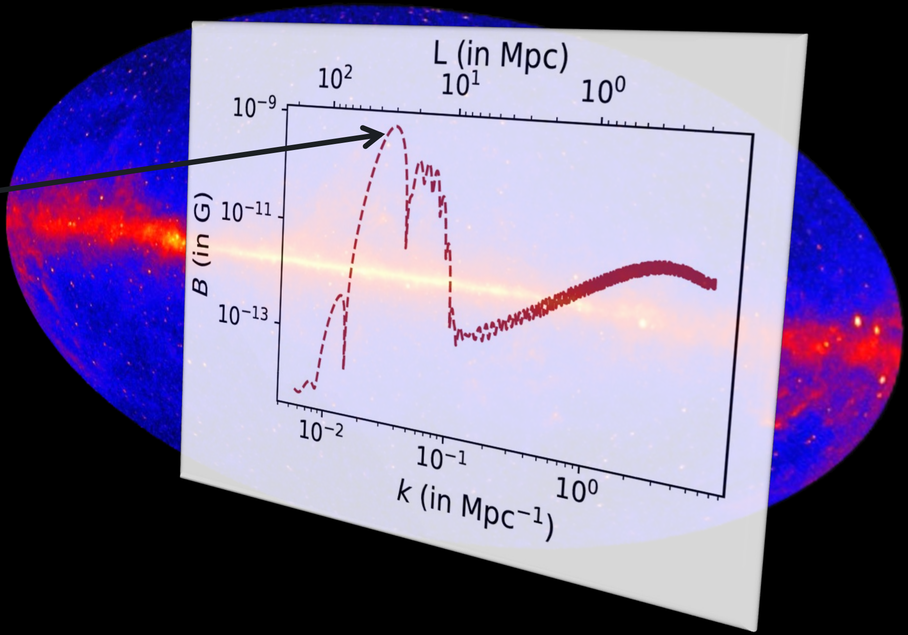
$$\frac{\chi}{4f}\lambda F^a_{\mu\nu}\tilde{F}^{a\,\mu\nu}$$



Backreaction effects lead to correlated signal in
gravitational waves & primordial magnetic fields

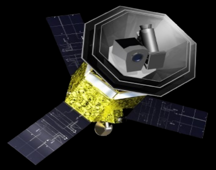



[LISA, LiteBIRD, SO]




[Fermi telescope, CTA, SKA]

# Characteristic signatures from gauge fields

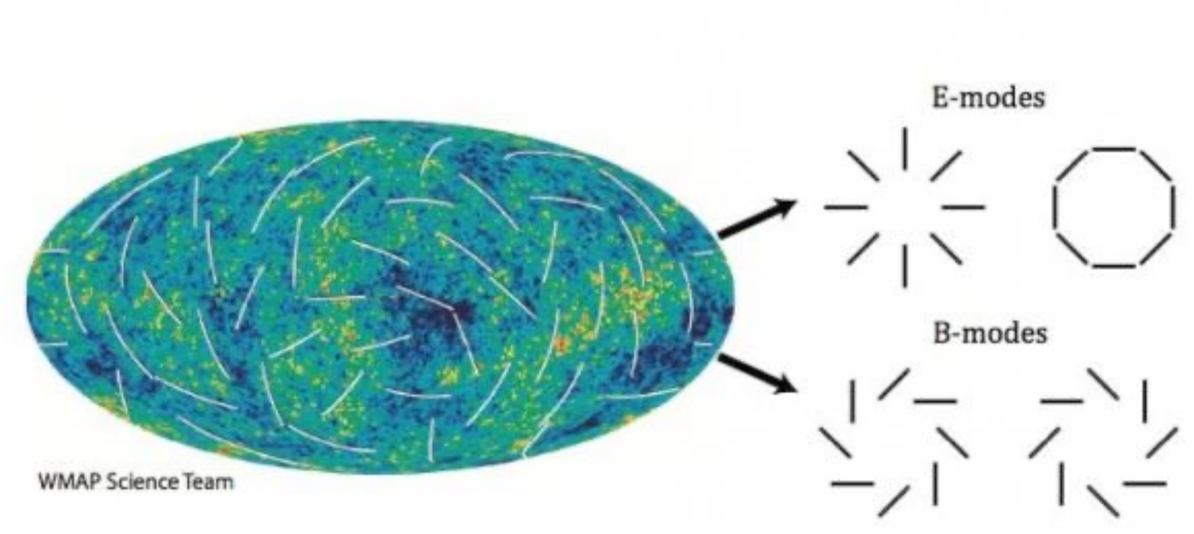


[Litebird]

- Polarization: B-modes

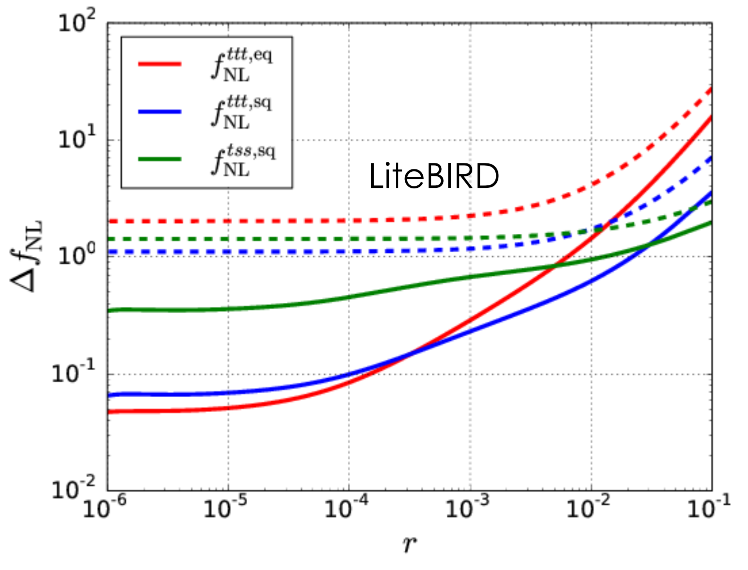
+ parity odd CMB correlations

$$TB \neq 0, EB \neq 0$$




[WMAP]

- Chiral gravitational waves
- Non-zero tensor non-Gaussianity




[M. Shiraishi, 2019]

# Dilution during inflation due to conformal invariance

$$A_\mu \sim 1/a(t)$$

$$f^2(\phi) F^a_{\mu\nu} F^{a\,\mu\nu}, \quad \chi F\tilde{F}, \quad \left(F\tilde{F}\right)^2$$

To avoid dilution, new terms in the gauge theory are required  or a coupling with inflaton!

# Spectator Chromo-natural inflation

$$-\frac{1}{2}(\partial\chi)^2 - \mu^4\left(1+\cos(\frac{\chi}{f})\right)$$

Natural inflation

[K. Freese, J. A. Frieman and A. V. Olinto, 1990]

# Spectator Chromo-natural inflation

$$-\frac{1}{2}(\partial\chi)^2 - \mu^4\left(1+\cos(\frac{\chi}{f})\right) - \frac{1}{4}F^a_{\mu\nu}F^{a\,\mu\nu} + \frac{\chi}{4f}\lambda F^a_{\mu\nu}\tilde{F}^{a\,\mu\nu}\Bigg]$$

Chromo-natural inflation

[P. Adshead , M. Wyman, 2012]

additional friction

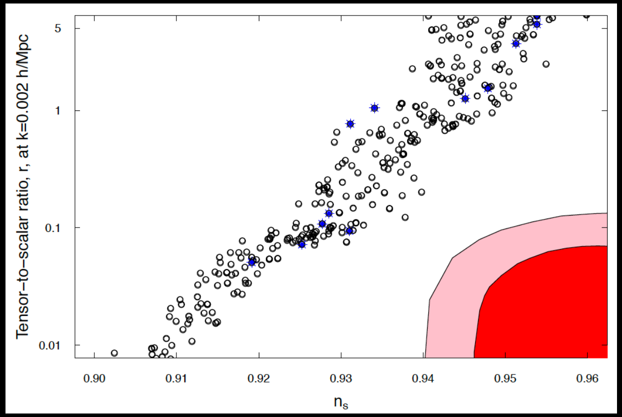
# Spectator Chromo-natural inflation

$$-\frac{1}{2}(\partial\chi)^2 - \mu^4\left(1+\cos(\frac{\chi}{f})\right) - \frac{1}{4}F^a_{\mu\nu}F^{a\,\mu\nu} + \frac{\chi}{4f}\lambda F^a_{\mu\nu}\tilde{F}^{a\,\mu\nu}\Bigg]$$

Chromo-natural inflation

additional friction

[P. Adshead , M. Wyman, 2012]




Ruled out by observations!

[P. Adshead, E. Martinec, and M. Wyman, 2013]

# Spectator Chromo-natural inflation

$$S = \int d^4x \sqrt{-\det(g_{\mu\nu})} \left[ \frac{M_{\rm Pl}^2}{2} R - \frac{1}{2}(\partial\phi)^2 - V(\phi) \right.$$
$$\left. - \frac{1}{2}(\partial\chi)^2 - \mu^4 \left(1 + \cos(\frac{\chi}{f})\right) - \frac{1}{4} F^a_{\mu\nu} F^{a\,\mu\nu} + \frac{\chi}{4f} \lambda F^a_{\mu\nu} \tilde{F}^{a\,\mu\nu} \right]$$

$$F^a_{\mu\nu} = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu - g\epsilon^{abc} A^b_\mu A^c_\nu$$

[E. Dimastrogiovanni, M. Fasiello, T. Fujita, 2017]

# Spectator Chromo-natural inflation

$$S = \int d^4x \sqrt{-\det(g_{\mu\nu})} \left[ \frac{M_{\rm Pl}^2}{2} R - \frac{1}{2}(\partial\phi)^2 - V(\phi) - \frac{1}{2}(\partial\chi)^2 - \mu^4 \left(1 + \cos(\frac{\chi}{f})\right) - \frac{1}{4} F^a_{\mu\nu} F^{a\,\mu\nu} + \frac{\chi}{4f} \lambda F^a_{\mu\nu} \tilde{F}^{a\,\mu\nu} \right]$$

$$F^a_{\mu\nu} = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu - g\epsilon^{abc} A^b_\mu A^c_\nu$$

[E. Dimastrogiovanni, M. Fasiello, T. Fujita, 2017]

Isotropic (attractor) solution for the background:

[A.Maleknejad and M.M.Sheikh-Jabbari, 2011]

$$A^a_0 = 0,$$

$$A^a_i = \delta^a_i a(t) Q(t)$$

“hedgehog ansatz”

# Dictionary of perturbations

Scalar perturbations:

- inflaton $\delta\phi$
- axion $\delta\chi$
- gauge field $\delta Q$
- metric $\varphi$

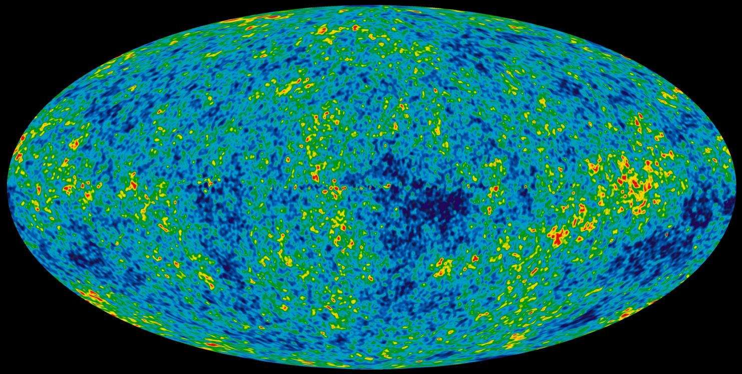
# Dictionary of perturbations

Scalar perturbations:

- inflaton $\delta\phi$
- axion $\delta\chi$
- gauge field $\delta Q$
- metric $\varphi$

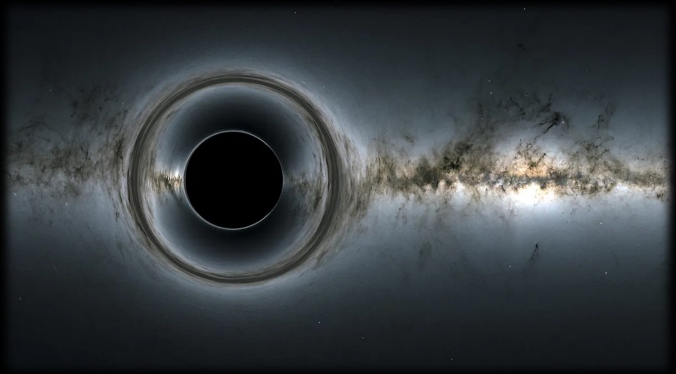
[E. Dimastrogiovanni, M. Fasiello, T. Fujita ,2017]
[A. Papageorgiou, M. Peloso, C. Unal, 2019]
[T. Fujita,T. Murata, I. Obata, M. Shiraishie, 2023]
...
[E. Dimastrogiovanni, M. Fasiello, A. Papageorgiou, 2024]

CMB



[Planck]

Primordial black holes



[NASA/ESA/Gaia/DPAC]

# Dictionary of perturbations

Tensor perturbations:

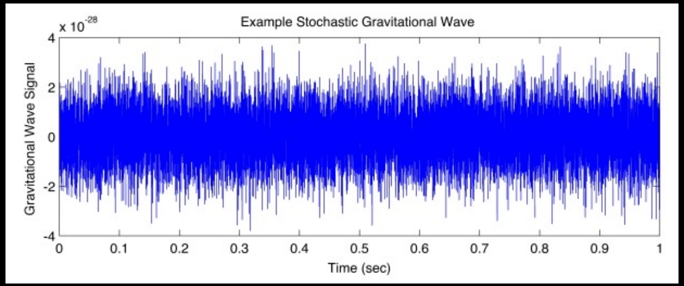
- metric $\delta g_{ij} \supset h_{ij} \supset \psi_{R,L}$
- gauge field $\delta A_i^a \supset T_{ia} \supset T_{R,L}$

# Dictionary of perturbations

Tensor perturbations:

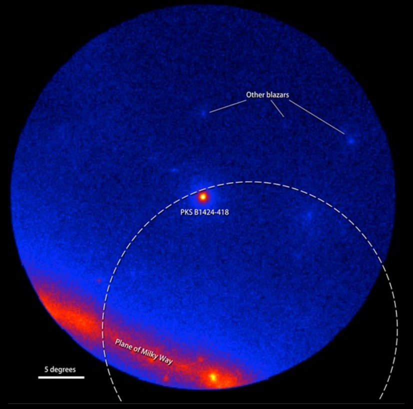
- metric $\delta g_{ij} \supset h_{ij} \supset \psi_{R,L}$
- gauge field $\delta A_i^a \supset T_{ia} \supset T_{R,L}$

Primordial graviational waves




[LIGO/VIRGO]

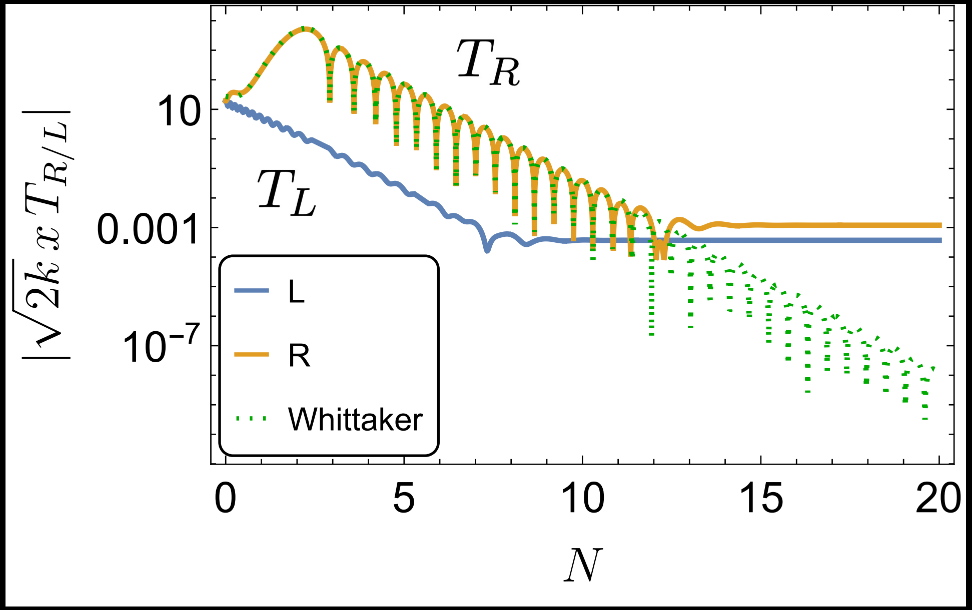
Primordial magnetic fields




[NASA/DOE/LAT Collaboration]

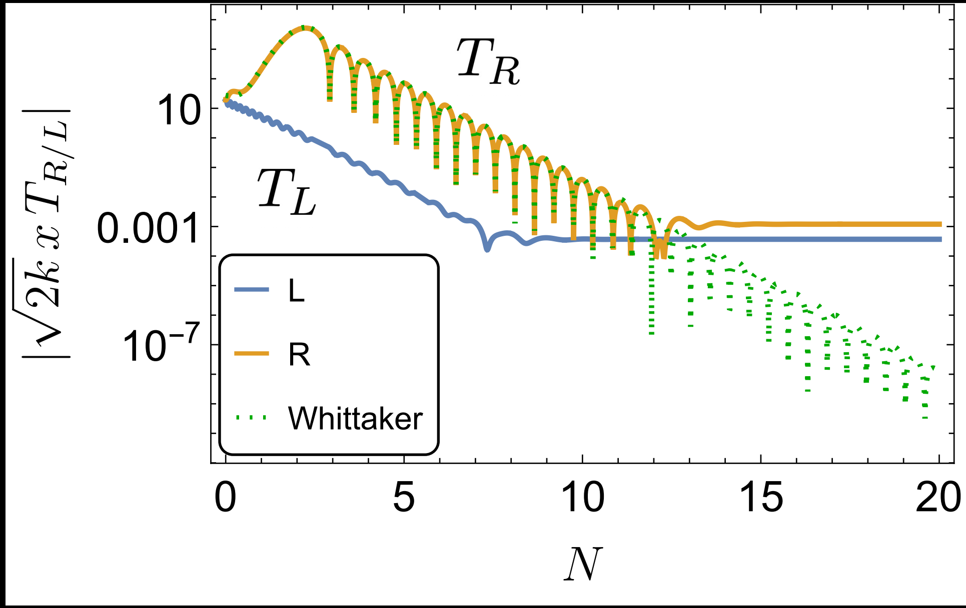
# Chiral GW production from tensor perturbations

$$\partial_x^2 T_{R,L} + \left[1 + \frac{2}{x^2}\left(m_Q\xi \mp x(m_Q + \xi)\right)\right] T_{R,L} = \tilde{f}(\psi_{R,L})$$



# Chiral GW production from tensor perturbations

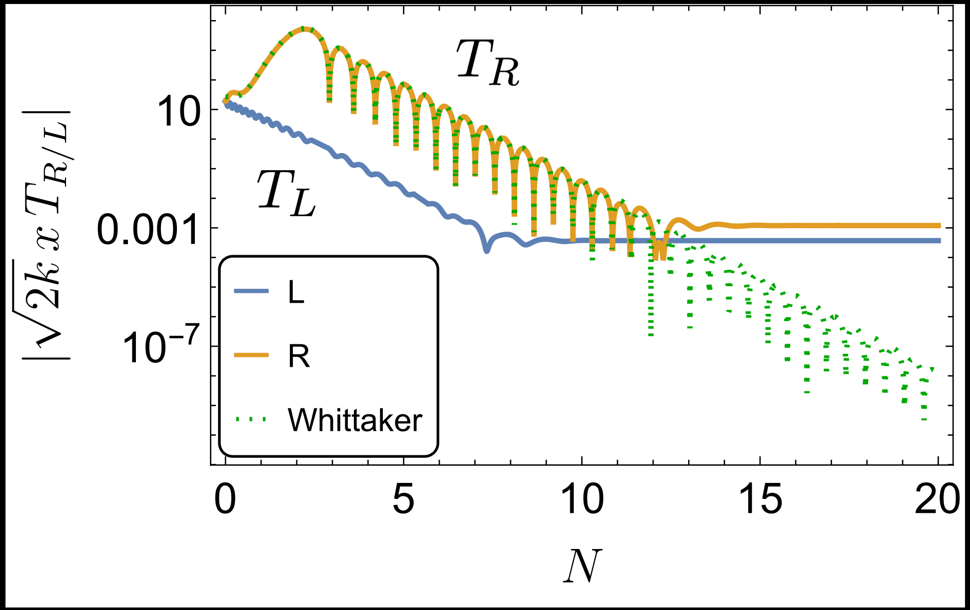
$$\partial_x^2 T_{R,L} + \left[1 + \frac{2}{x^2}\left(m_Q\xi \mp x(m_Q + \xi)\right)\right] T_{R,L} = \tilde{f}(\psi_{R,L})$$




Transient tachyonic instability only in one of polarizations

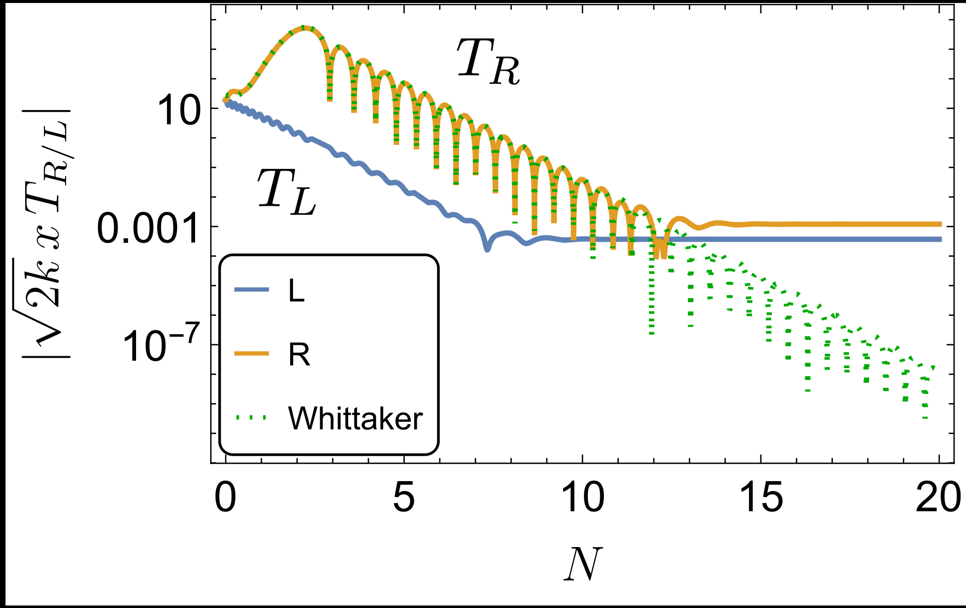
# Chiral GW production from tensor perturbations

$$\partial_x^2 T_{R,L} + \left[1 + \frac{2}{x^2}\left(m_Q\xi \mp x(m_Q+\xi)\right)\right] T_{R,L} = \tilde{f}(\psi_{R,L})$$



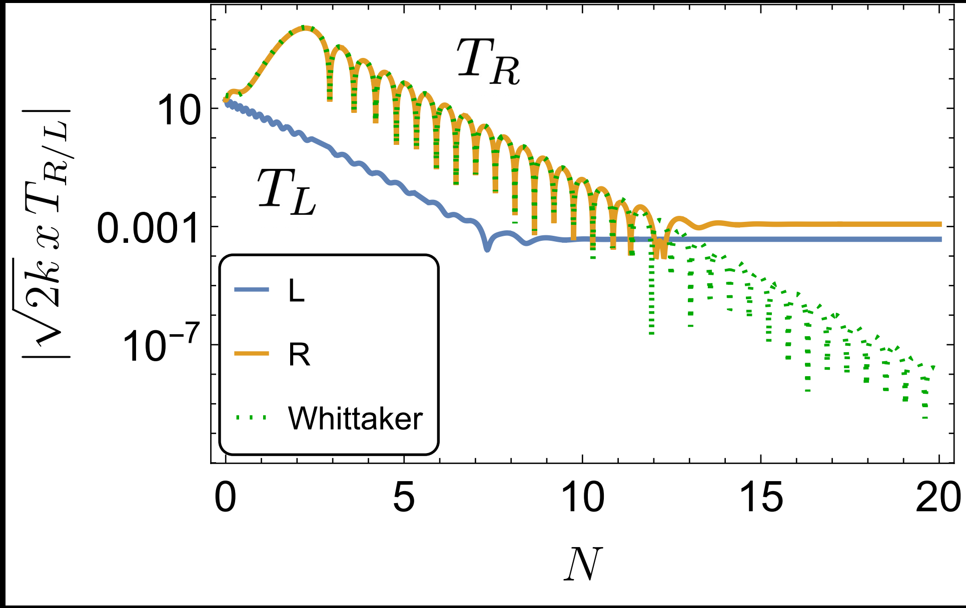
# Chiral GW production from tensor perturbations

$$\partial_x^2 T_{R,L} + \left[1 + \frac{2}{x^2}\left(m_Q\xi \mp x(m_Q+\xi)\right)\right] T_{R,L} = \tilde{f}(\psi_{R,L})$$



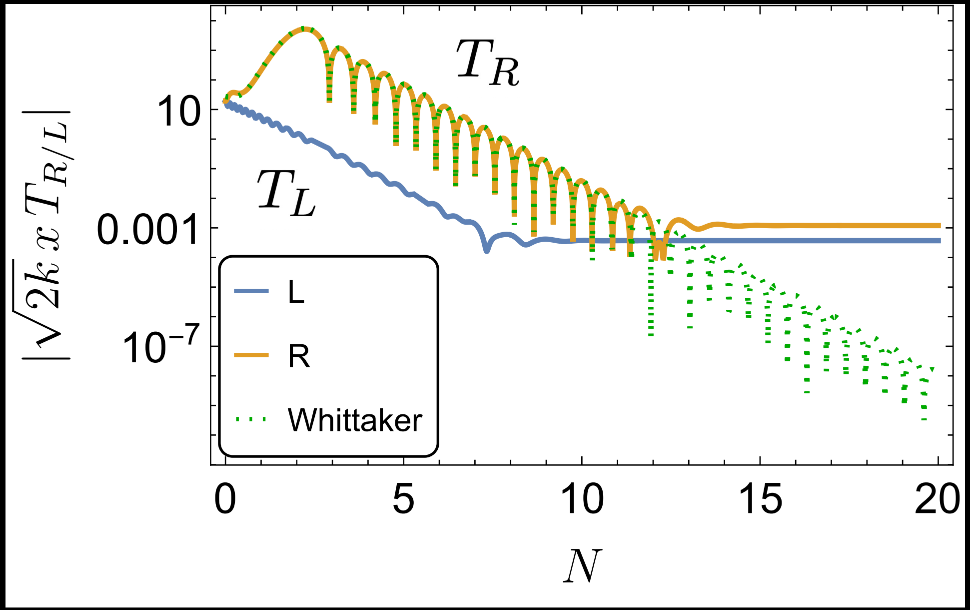
# Chiral GW production from tensor perturbations

$$\partial_x^2 T_{R,L} + \left[1 + \frac{2}{x^2}\left(m_Q\xi \mp x(m_Q + \xi)\right)\right] T_{R,L} = \tilde{f}(\psi_{R,L})$$



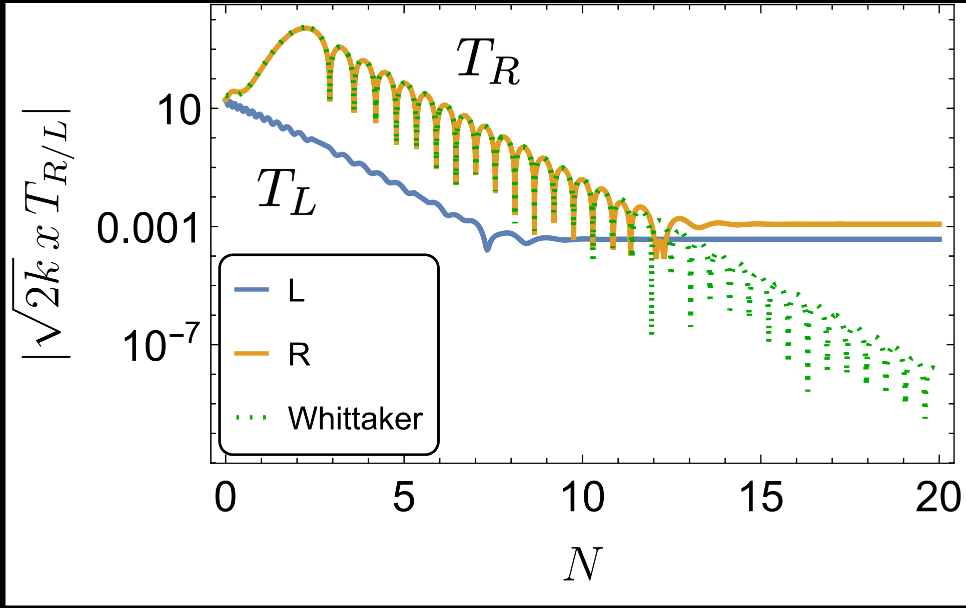

# Chiral GW production from tensor perturbations

$$\partial_x^2 T_{R,L} + \left[1 + \frac{2}{x^2}\left(m_Q\xi \mp x(m_Q + \xi)\right)\right] T_{R,L} = \tilde{f}(\psi_{R,L})$$



# Chiral GW production from tensor perturbations

$$\partial_x^2 T_{R,L} + \left[1 + \frac{2}{x^2}\left(m_Q\xi \mp x(m_Q+\xi)\right)\right] T_{R,L} = \tilde{f}(\psi_{R,L})$$

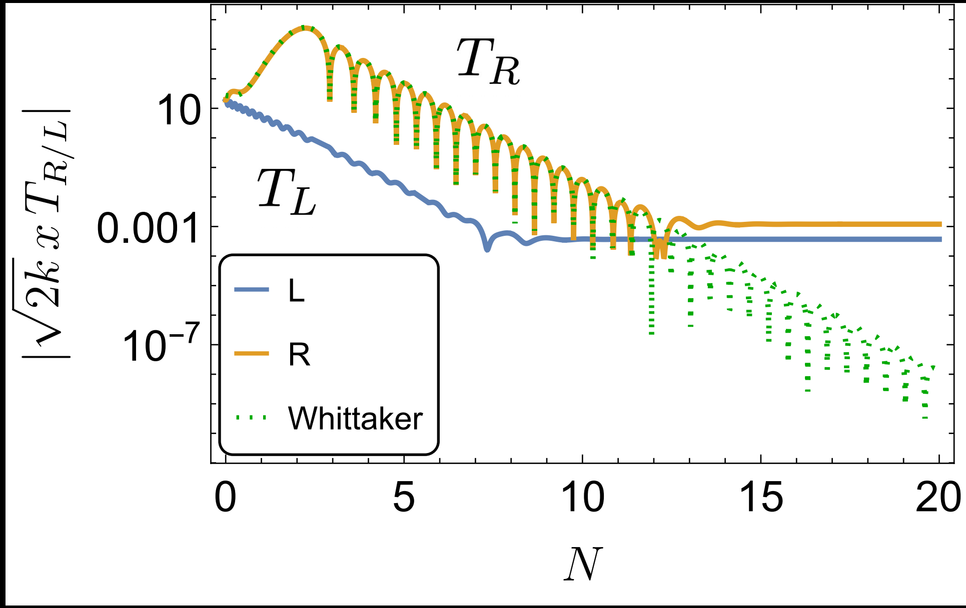


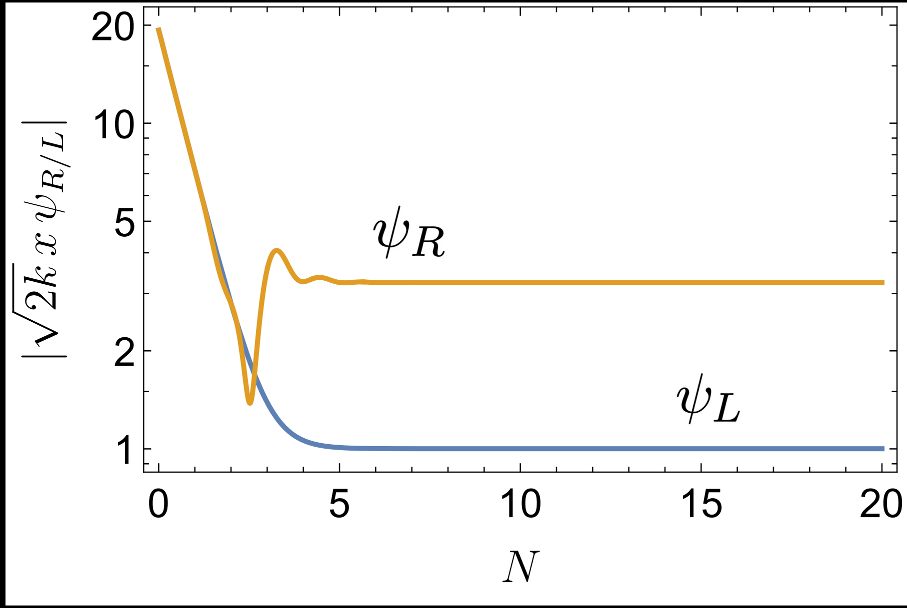

chirality

$T_R(x) \gg T_L(x)$

# Chiral GW production from tensor perturbations

$$\partial_x^2 \psi_{R,L} + \left(1 - \frac{2}{x^2}\right)\psi_{R,L} = f(T_{R,L})$$

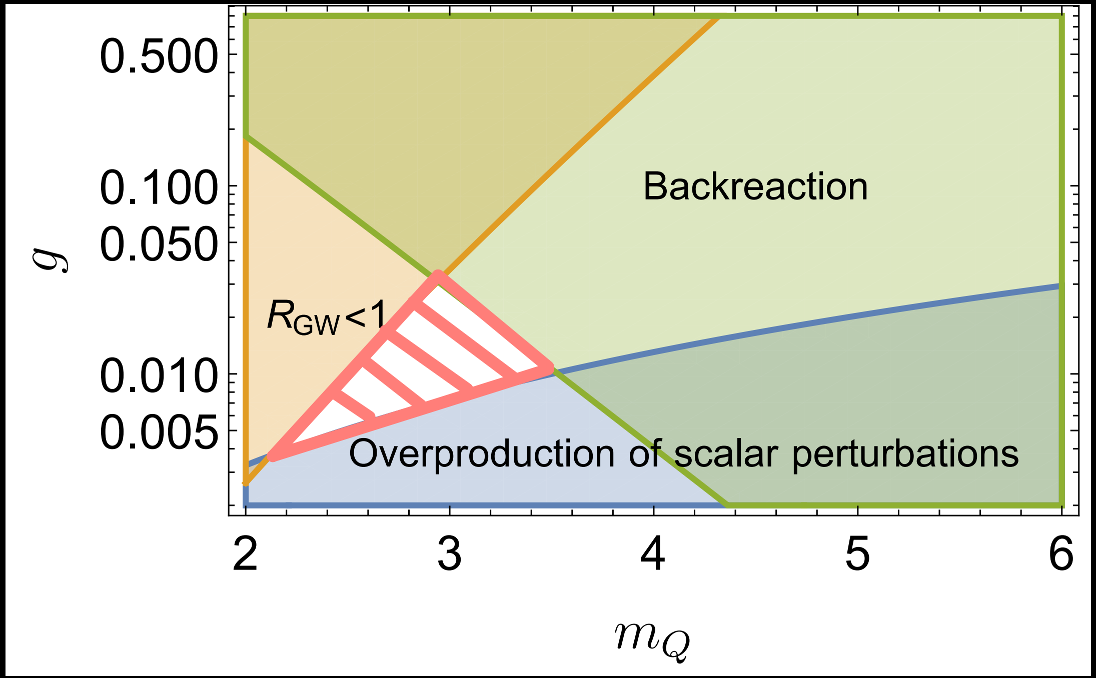


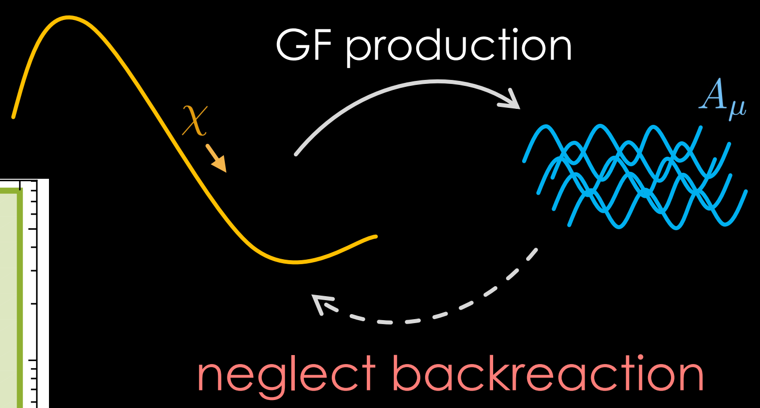




Chiral gravitational waves! $\psi_R(x) \gg \psi_L(x)$

# Viable parameter space of spectator axion-SU(2) inflation

$$\mathcal{R}_{\rm GW} = \frac{\mathcal{P}_h^{(s)}}{\mathcal{P}_h^{(v)}} \qquad m_Q = \frac{gQ}{H}$$

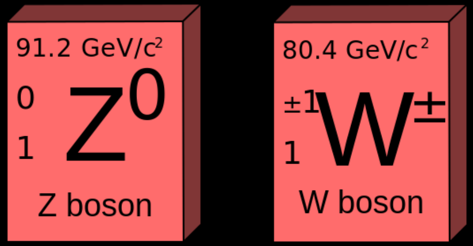


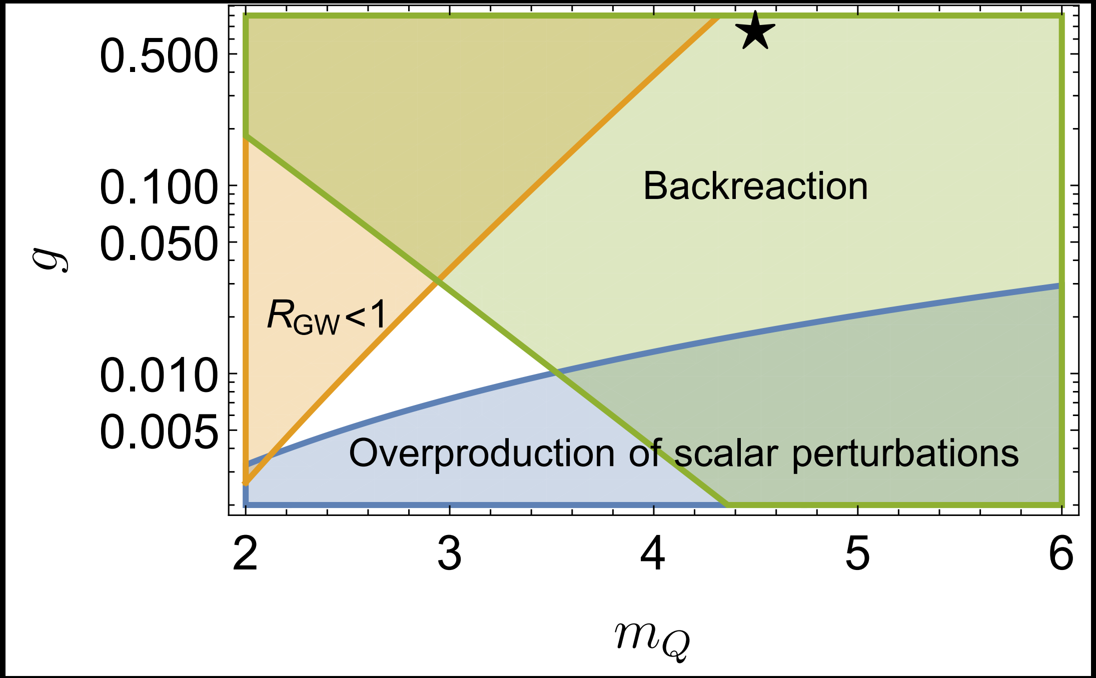

[E. Dimastrogiovanni, M. Fasiello and T. Fujita, 2017]
[A.Papageorgiou, M. Peloso, C. Unal, 2019]

# Identifying Standard Model weak bosons as the SU(2) sector

$\mathrm{SU}(2) \longleftrightarrow$

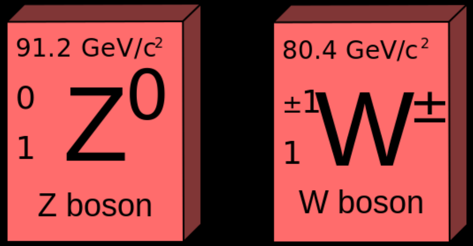



$g \propto \mathcal{O}(0.1)$

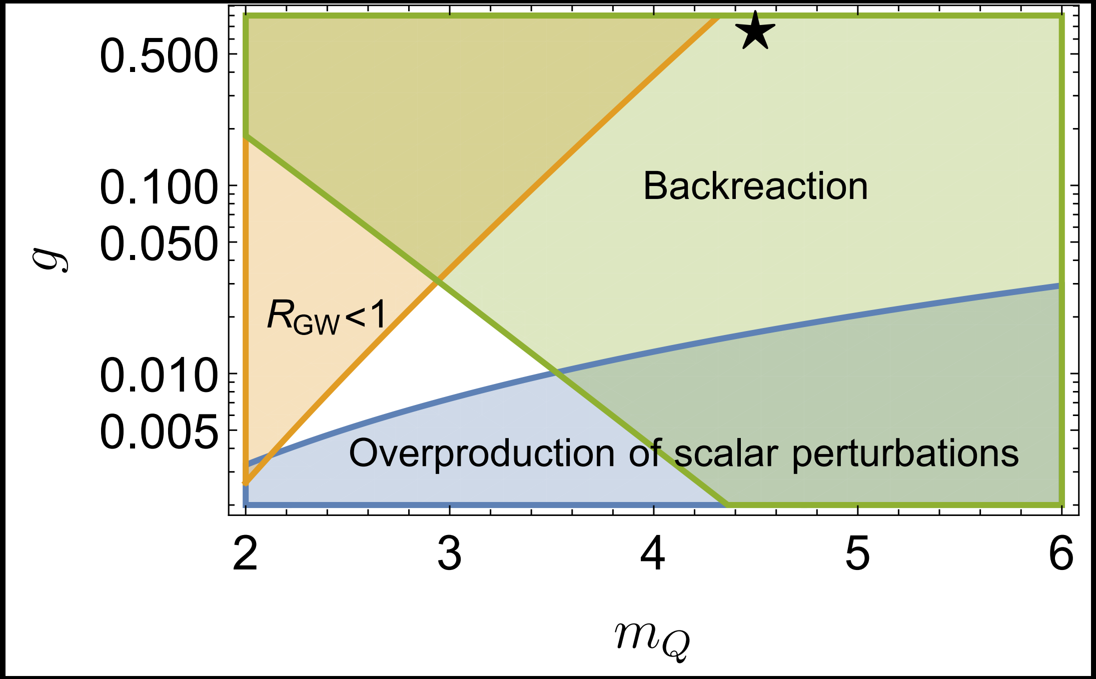


# Identifying Standard Model weak bosons as the SU(2) sector

$\mathrm{SU}(2) \longleftrightarrow$




$g \propto \mathcal{O}(0.1)$



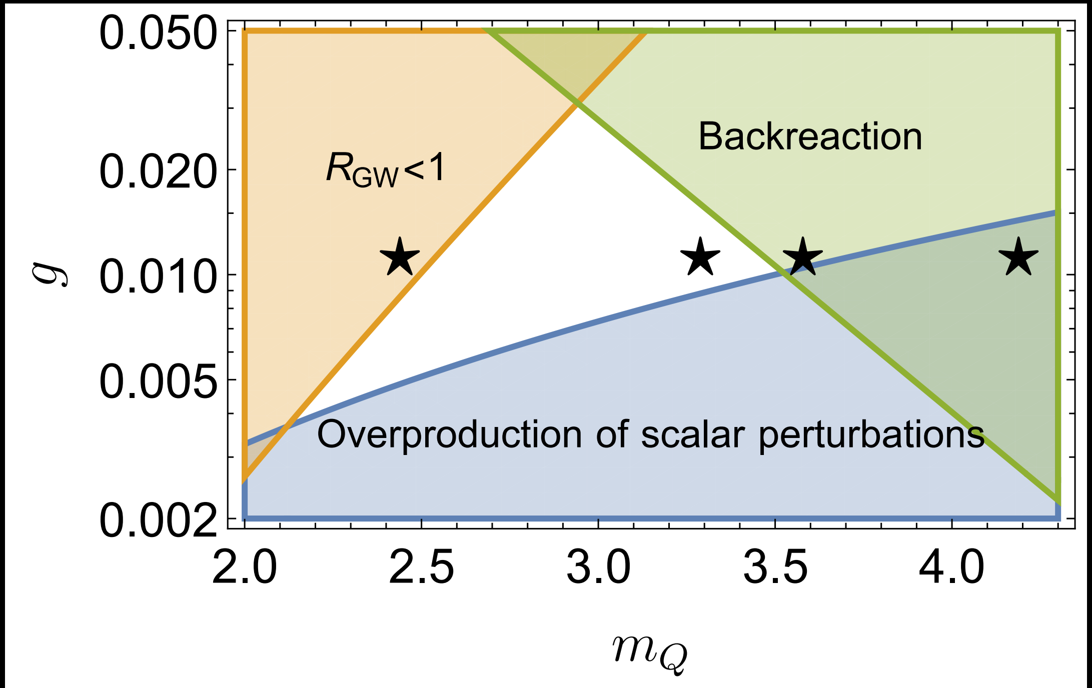

We need to know the dynamics in

the backreaction regime!

# Fiducial parameters for numerical simulations

The Pencil Code

[OI, E. I. Sfakianakis, R. Sharma, A. Brandenburg, 2023]

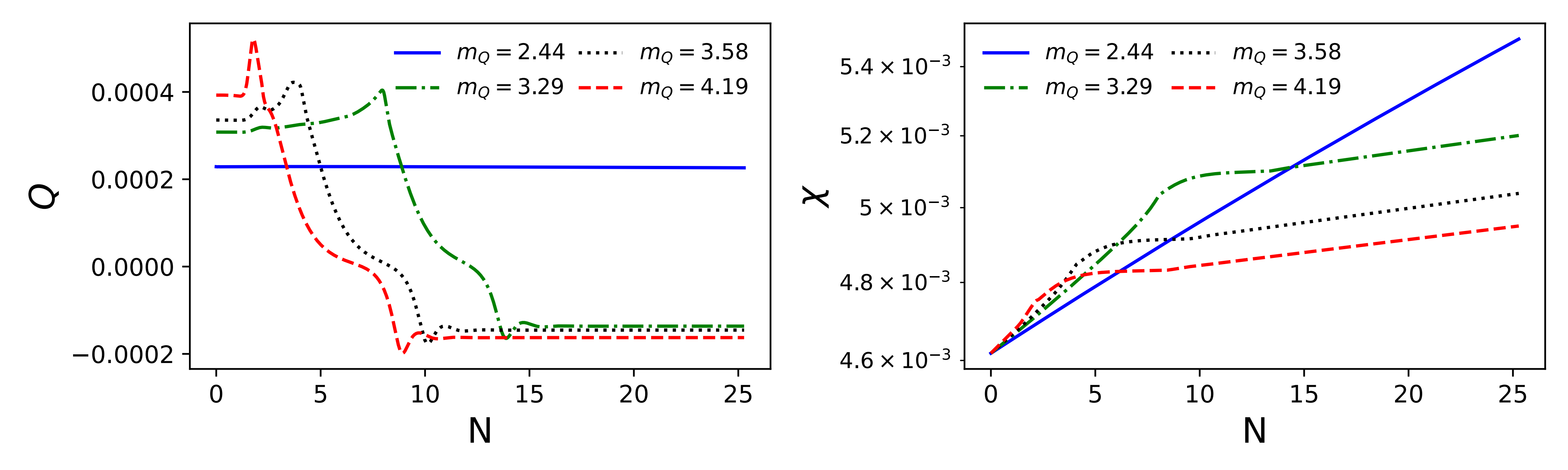



$$F^a_{\mu\nu} = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu - g\epsilon^{abc} A^b_\mu A^c_\nu$$

$$m_Q = \frac{gQ}{H}$$

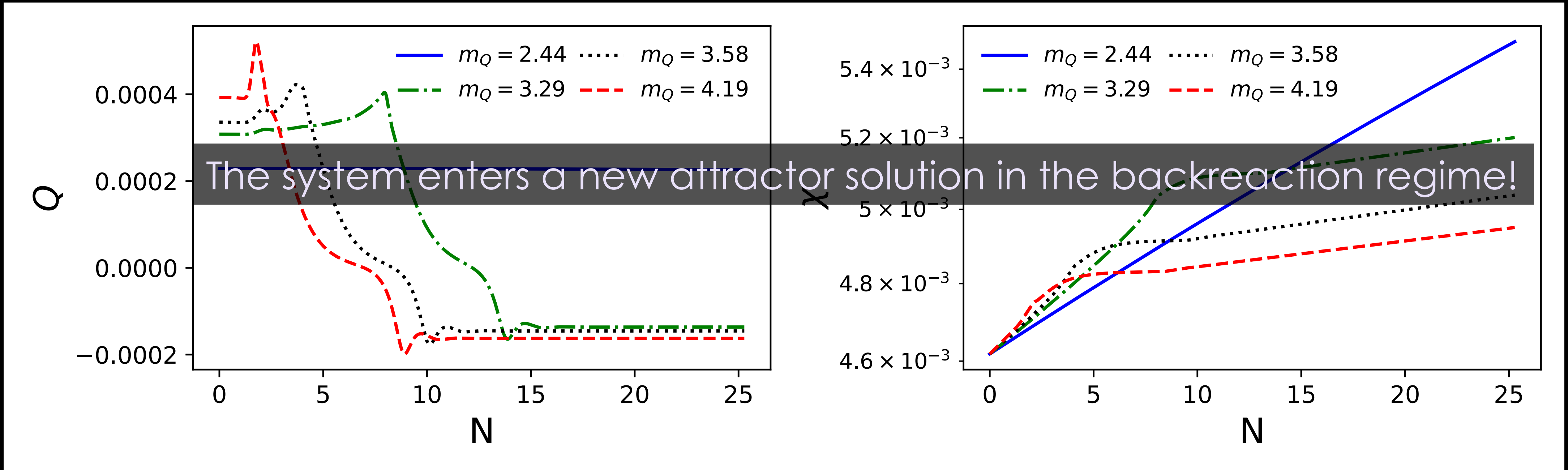
# Novel backreaction-supported attractor

[OI, E. I. Sfakianakis, R. Sharma, A. Brandenburg, 2023]



# Novel backreaction-supported attractor

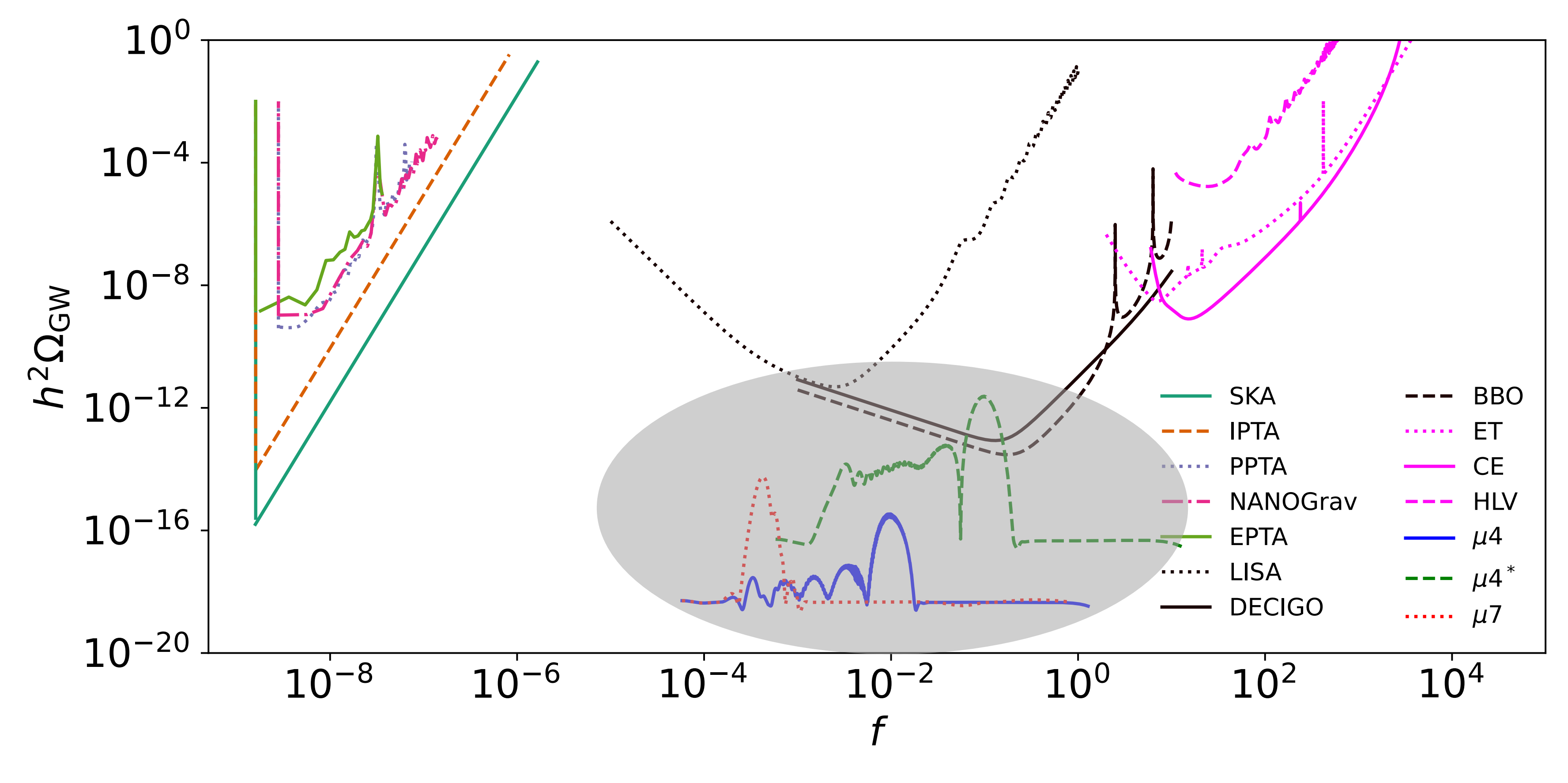
[OI, E. I. Sfakianakis, R. Sharma, A. Brandenburg, 2023]




The system enters a new attractor solution in the backreaction regime!

$$\frac{\lambda}{af}\chi' \simeq -\frac{2H^2}{gQ}, \qquad Q \simeq \text{const}$$

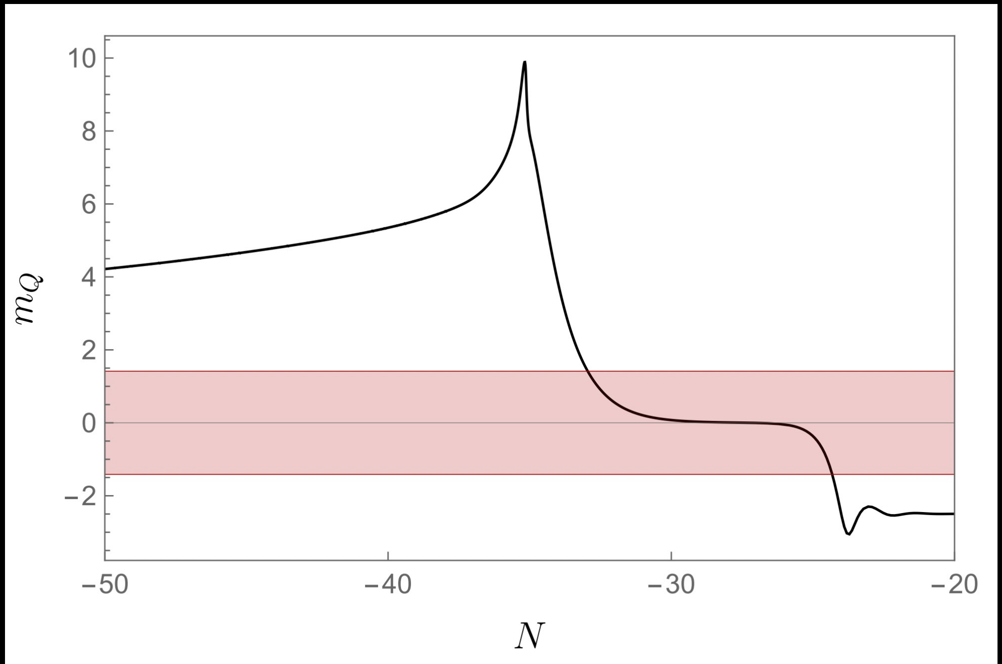
# Oscillatory features in gravitational waves

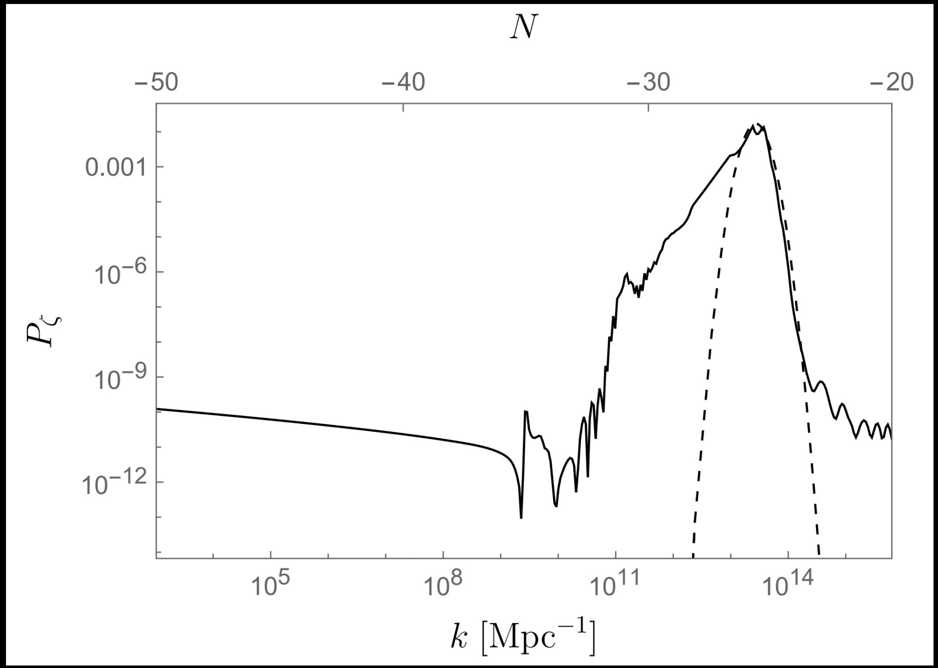



[OI, E. I. Sfakianakis, R. Sharma, A. Brandenburg, 2023]

# Primordial black holes in the backreaction regime

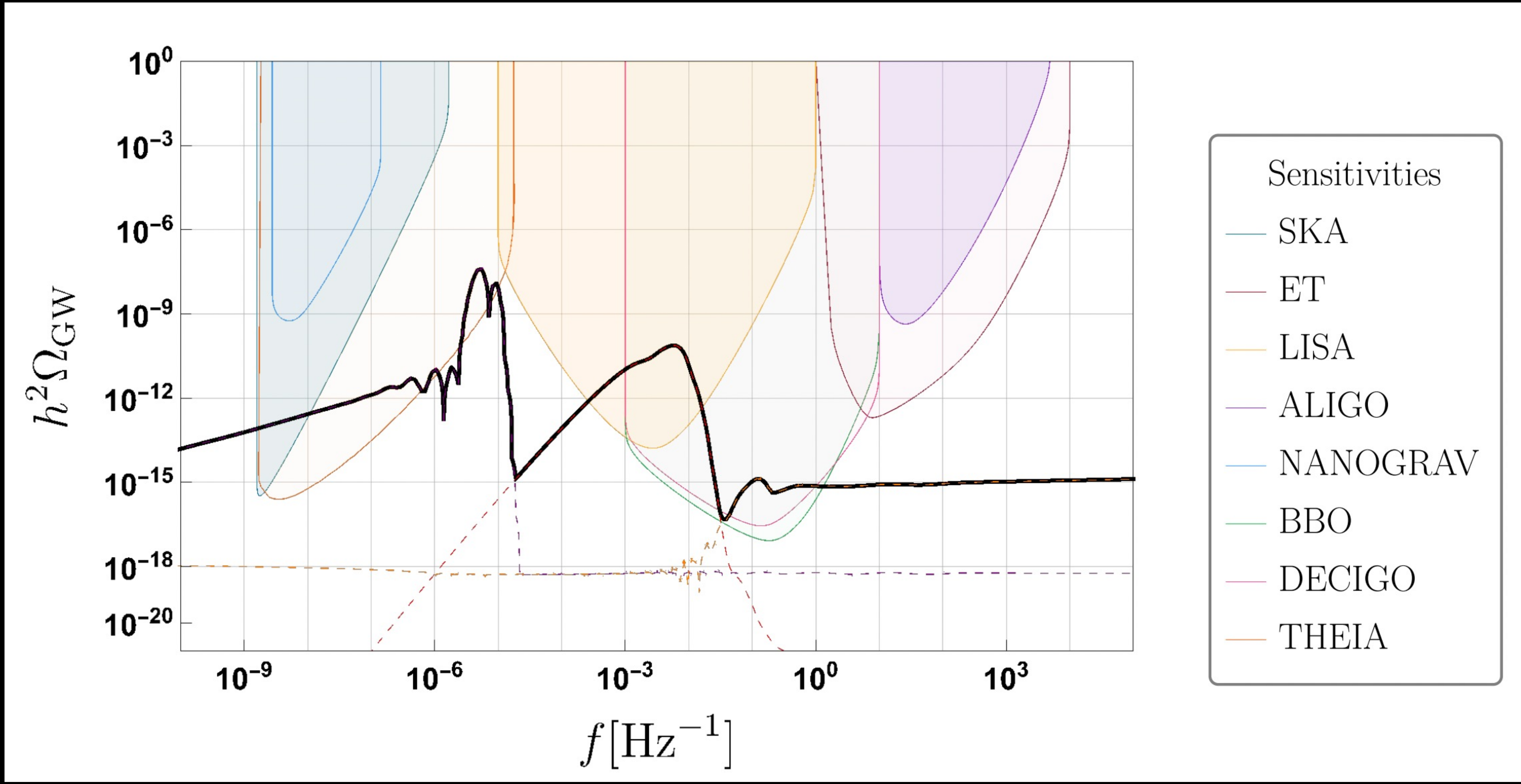
$|m_Q| < \sqrt{2}$ instability band leads to primordial black holes production



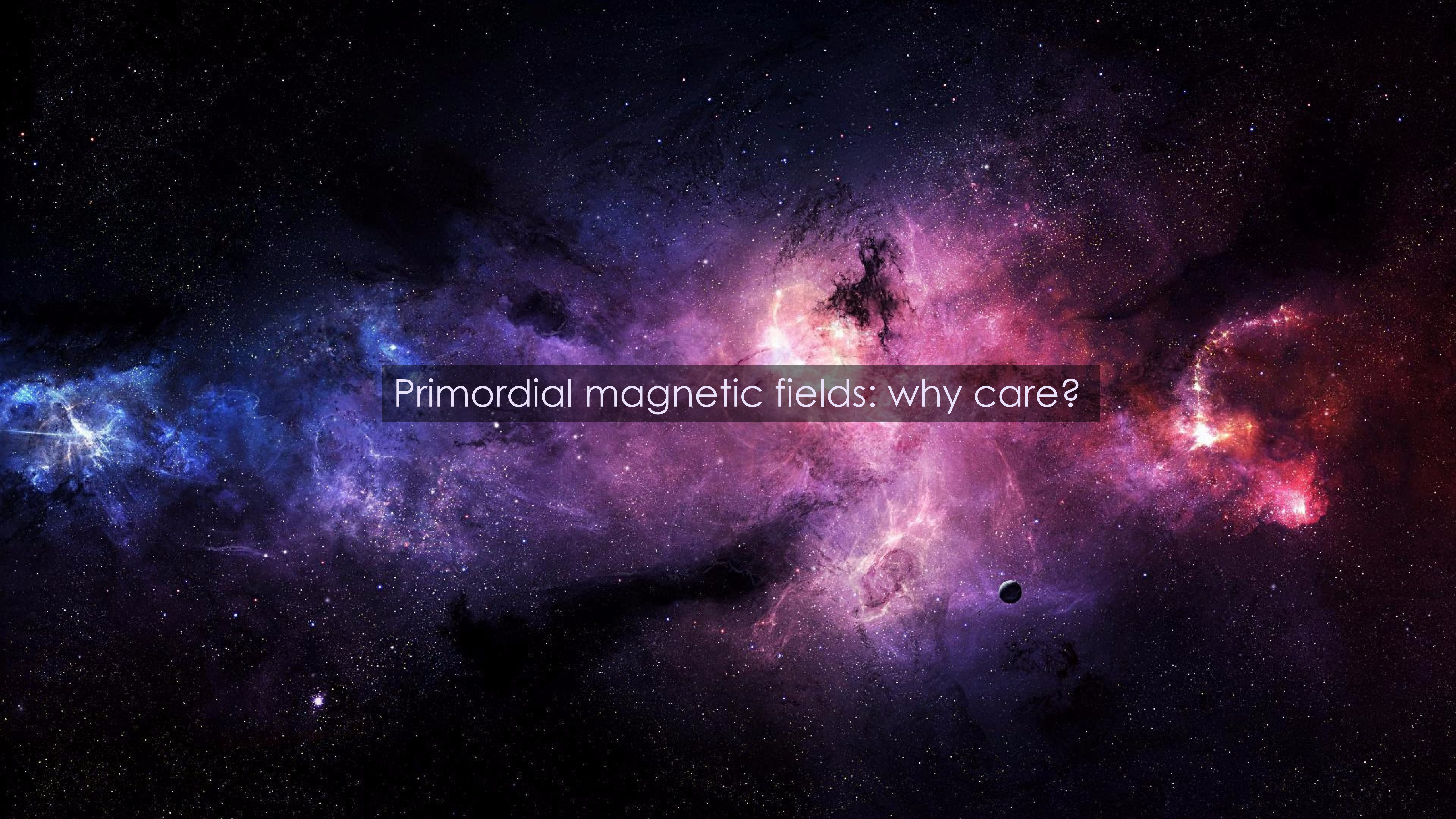




[E. Dimastrogiovanni, M. Fasiello, A. Papageorgiou, 2024]

# Gravitational waves and scale-dependent chirality



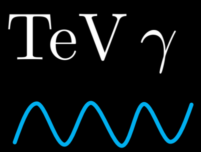

[E. Dimastrogiovanni, M. Fasiello, A. Papageorgiou, and C. Zenteno Gatica, 2025]


Primordial magnetic fields: why care?

# Primordial magnetic fields in intergalactic voids from blazar observations

Blazar

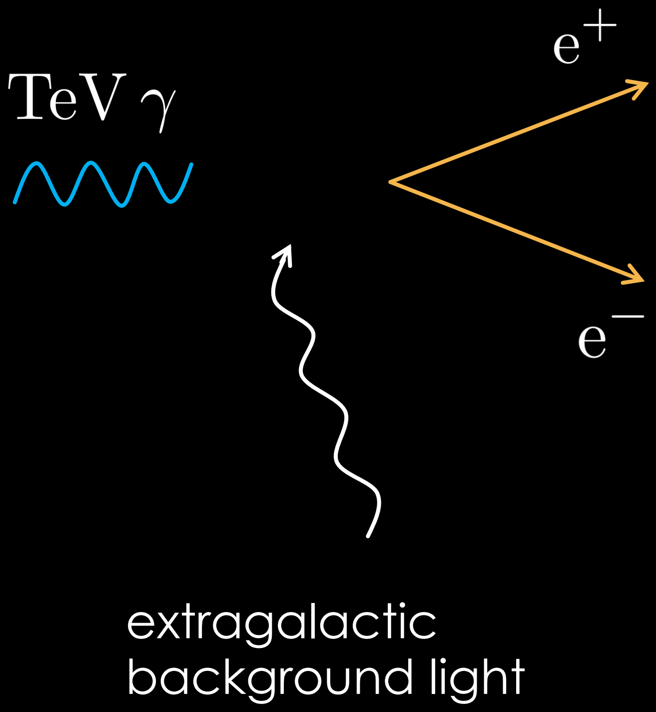
[NASA/JPL-Caltech]



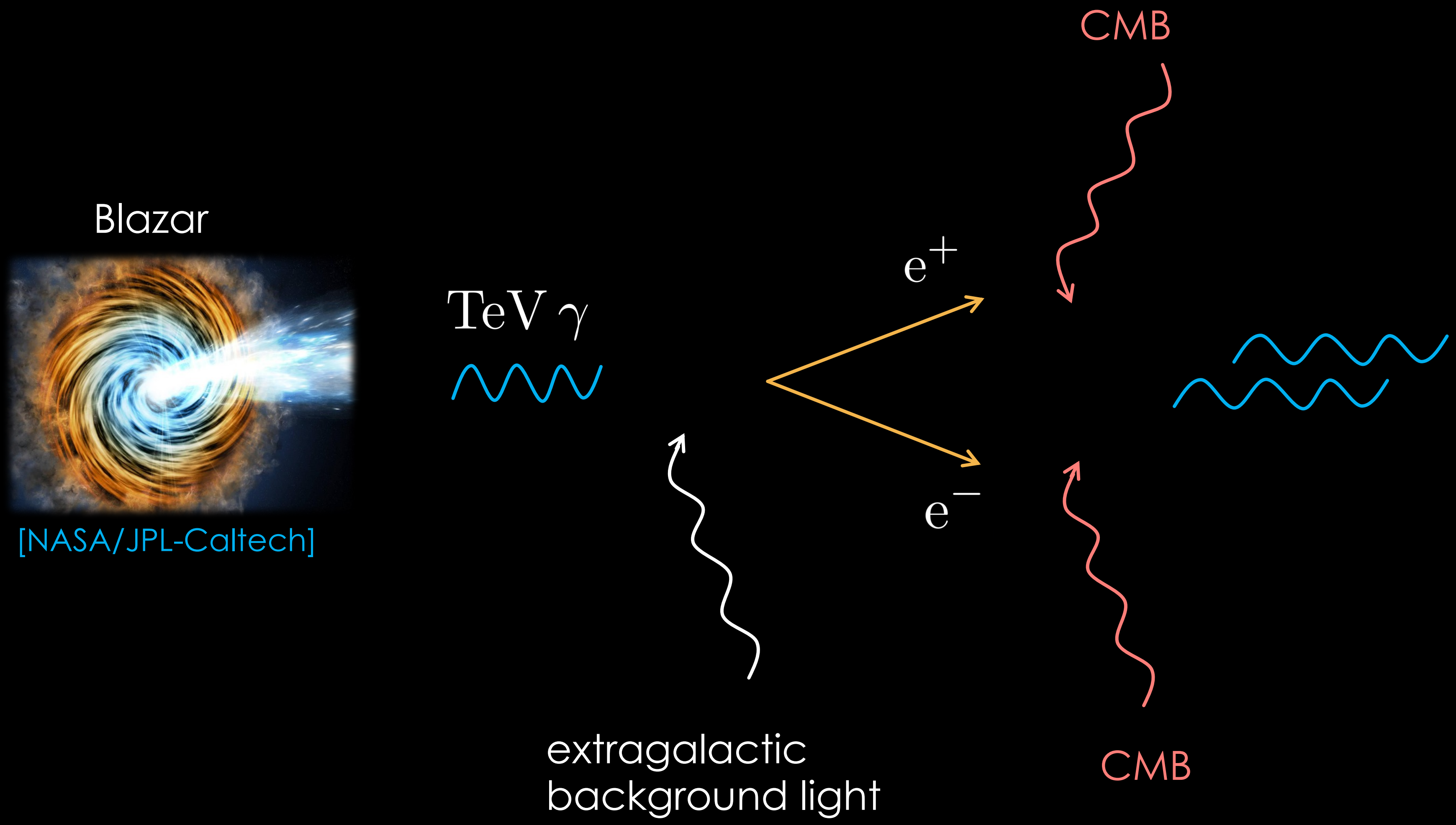
# Primordial magnetic fields in intergalactic voids from blazar observations

Blazar

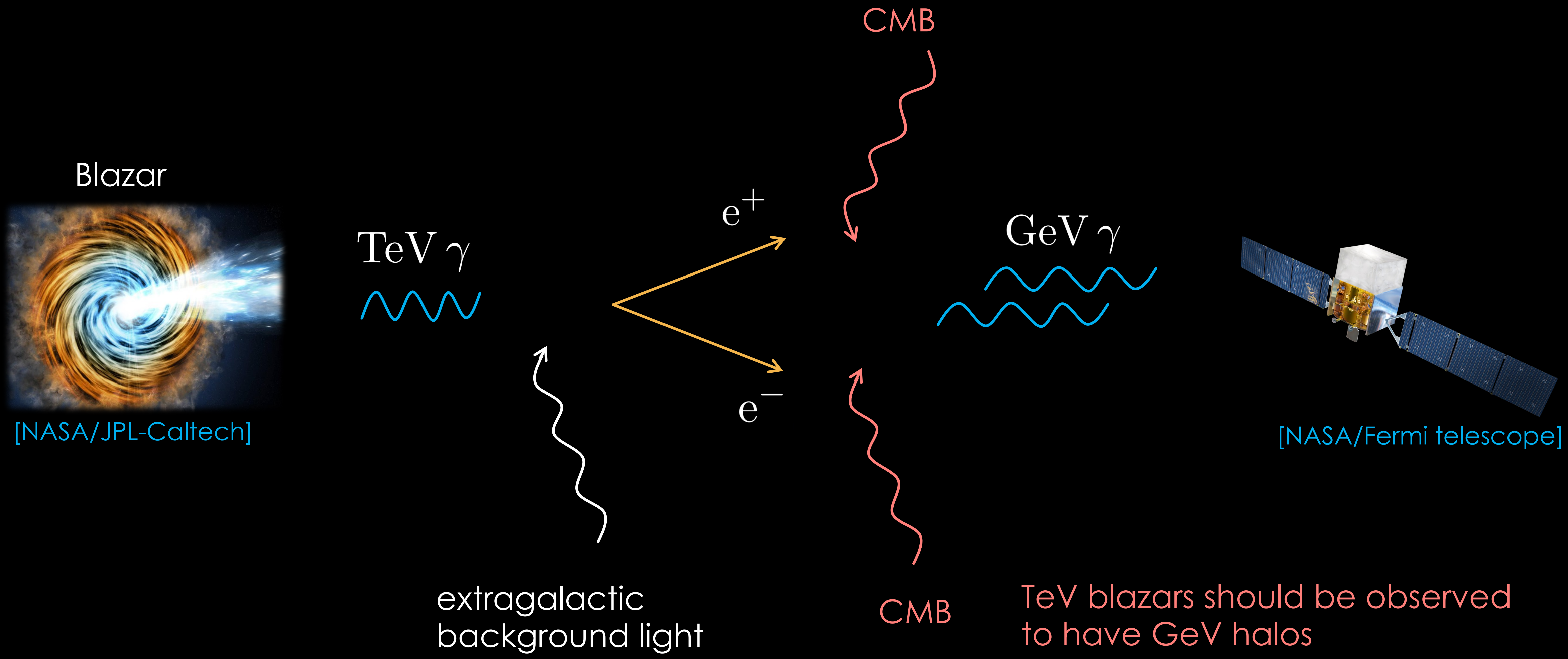
[NASA/JPL-Caltech]



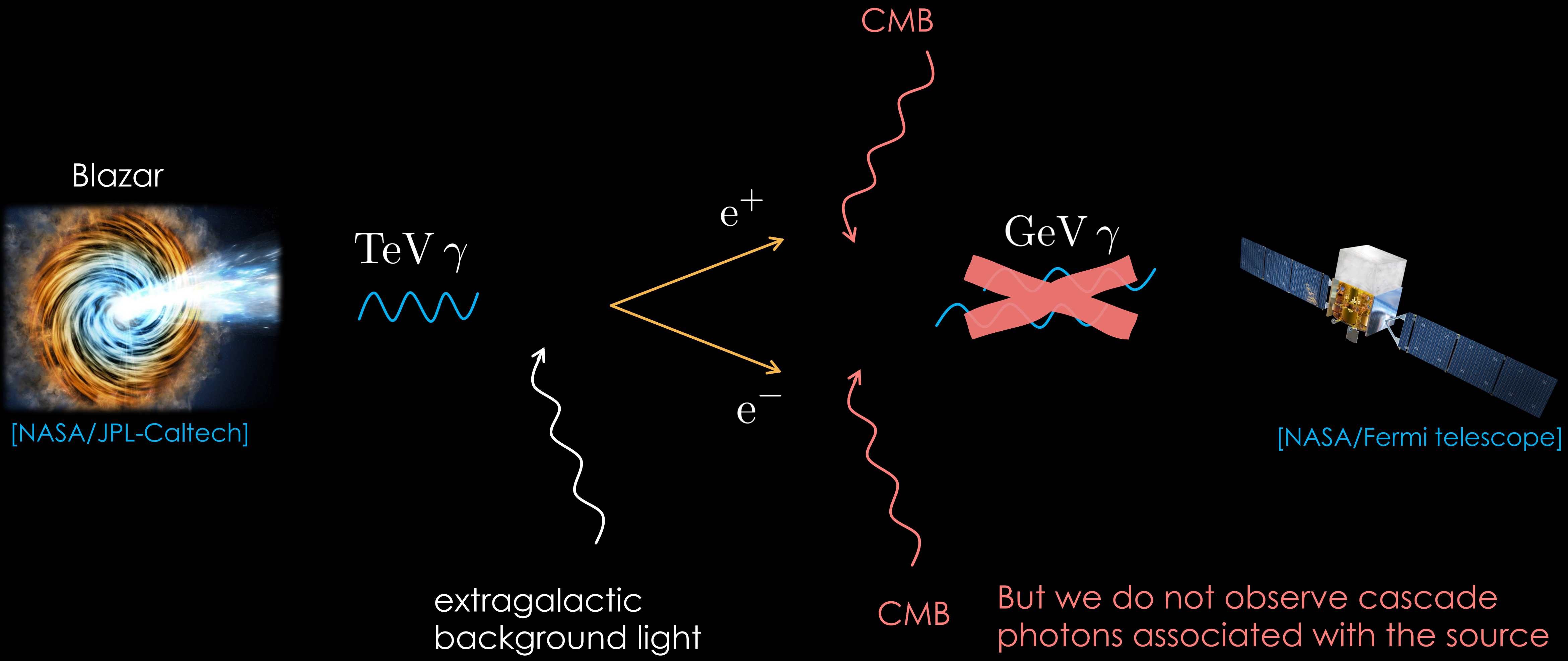
# Primordial magnetic fields in intergalactic voids from blazar observations



# Primordial magnetic fields in intergalactic voids from blazar observations



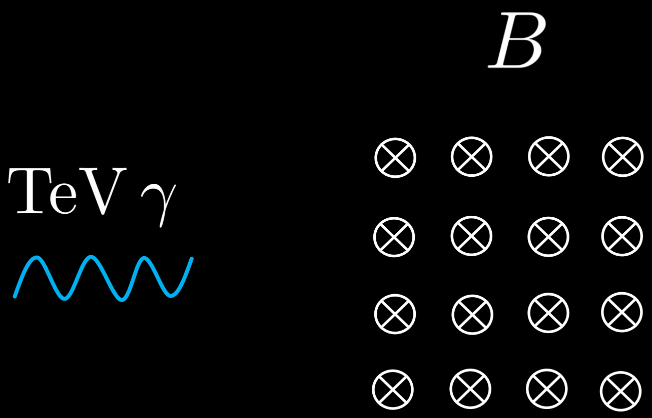
# Primordial magnetic fields in intergalactic voids from blazar observations

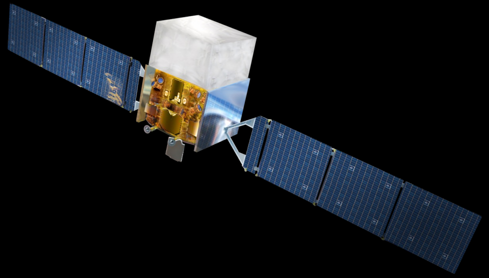


# Primordial magnetic fields in intergalactic voids from blazar observations

Blazar

[NASA/JPL-Caltech]



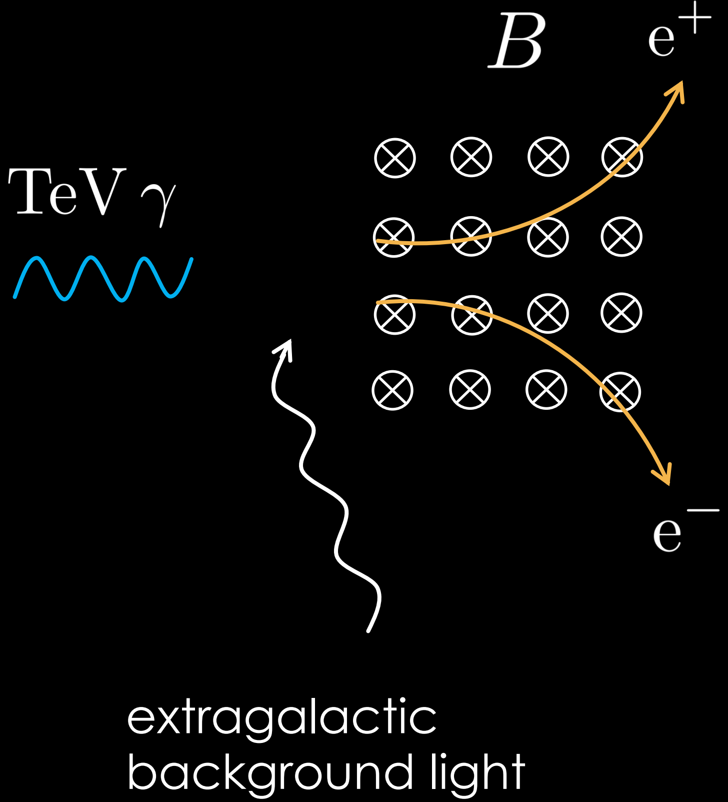



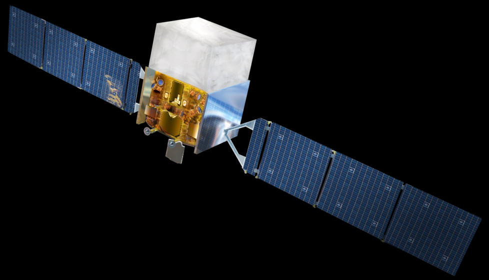
[NASA/Fermi telescope]

# Primordial magnetic fields in intergalactic voids from blazar observations

Blazar

[NASA/JPL-Caltech]



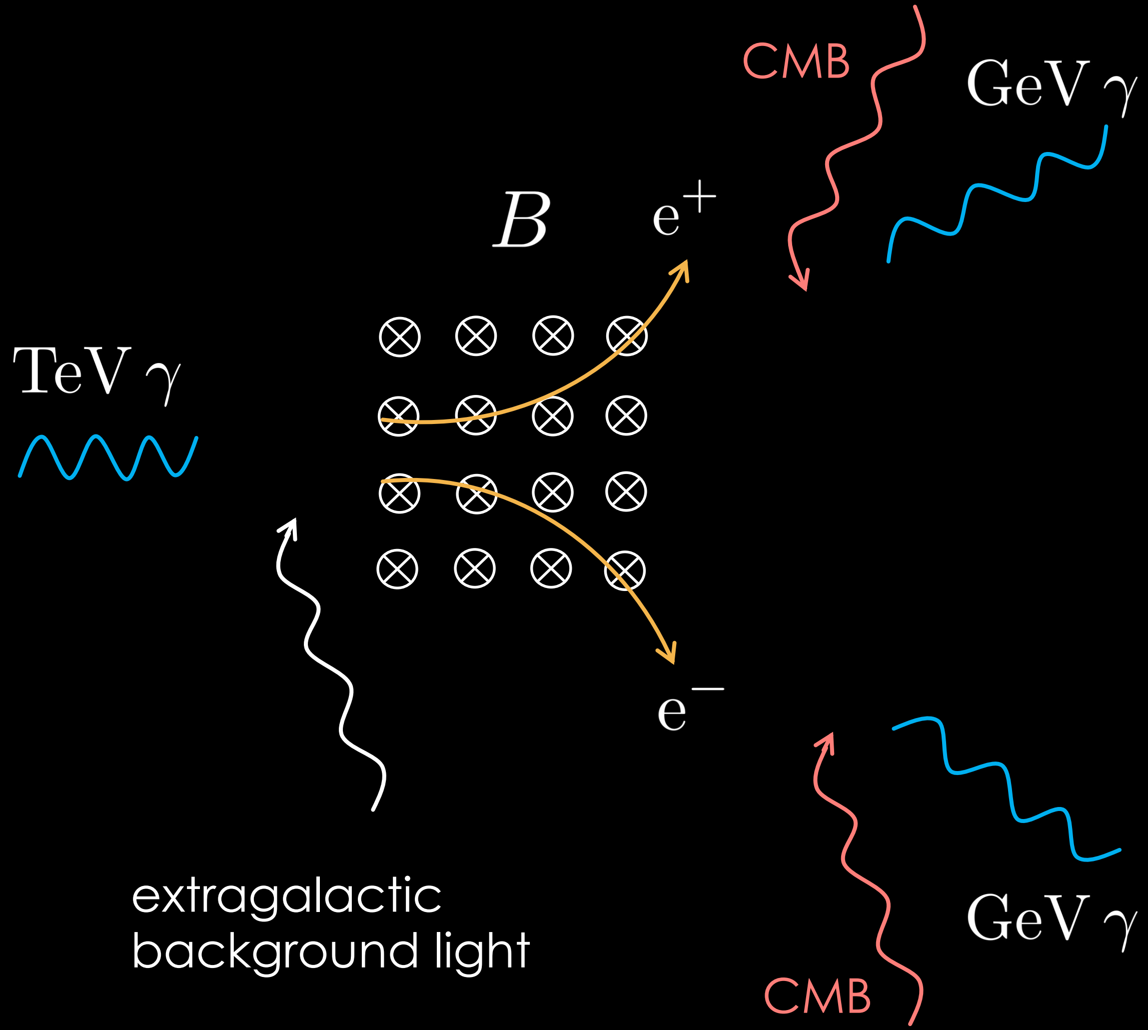



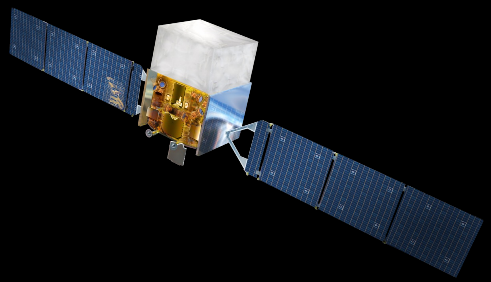
[NASA/Fermi telescope]

# Primordial magnetic fields in intergalactic voids from blazar observations

Blazar

[NASA/JPL-Caltech]



[NASA/Fermi telescope]

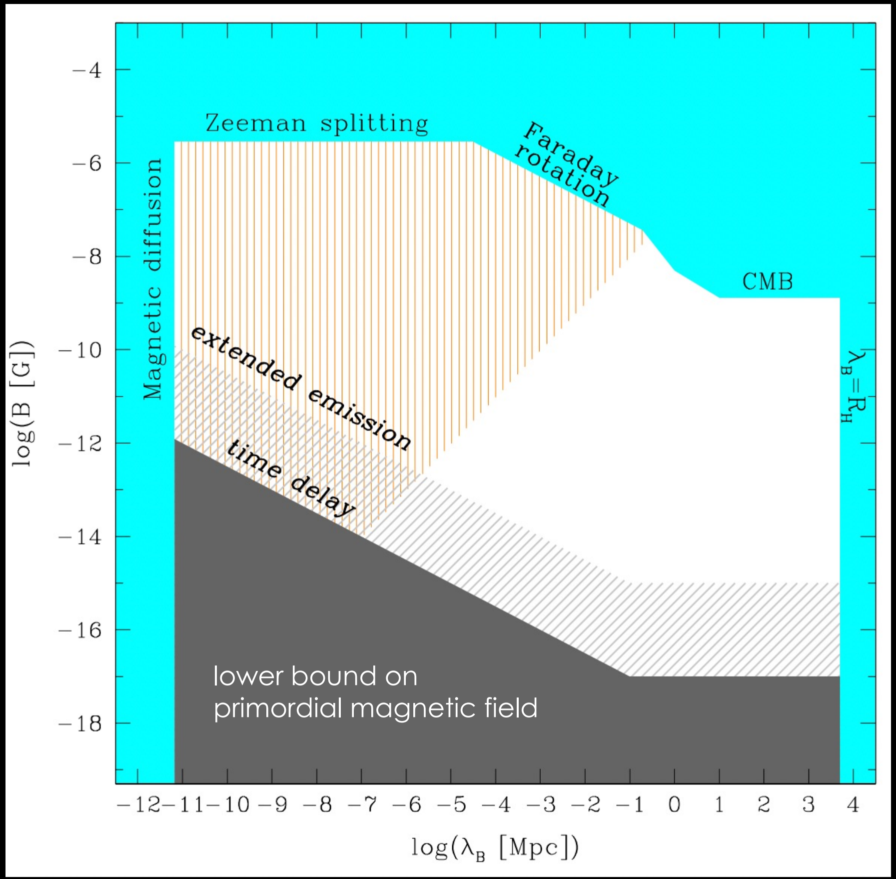
# Primordial magnetic fields in intergalactic voids from blazar observations

$B \gtrsim 10^{-15}\mathrm{G}$ with correlation length $\gtrsim$ Mpc

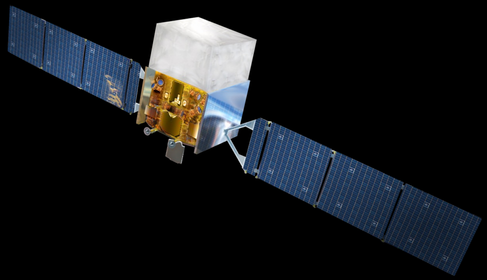
Blazar

[NASA/JPL-Caltech]

TeV $\gamma$



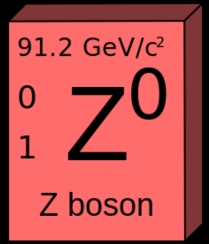

[A. M. Taylor, I. Vovk and A. Neronov, 2013]

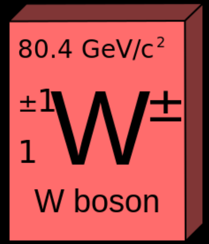


[NASA/Fermi telescope]

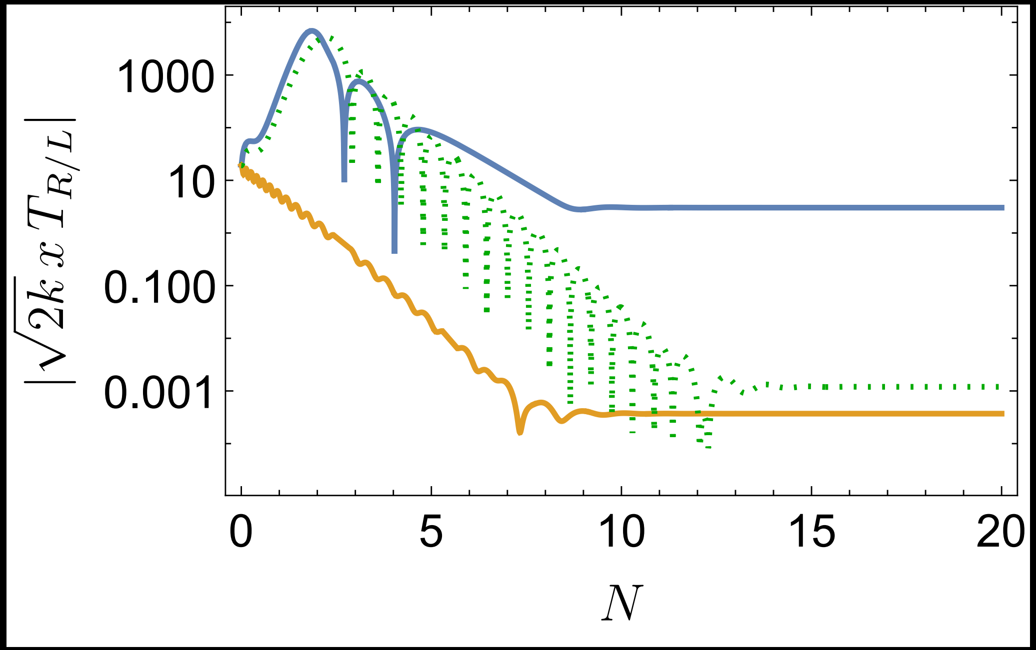
[Tavecchio et al, 2010; Neronov, Vovk, 2010;
Ando, Kusenko, 2010; Chen et al. 2014; Fermi-LAT 2018; …]

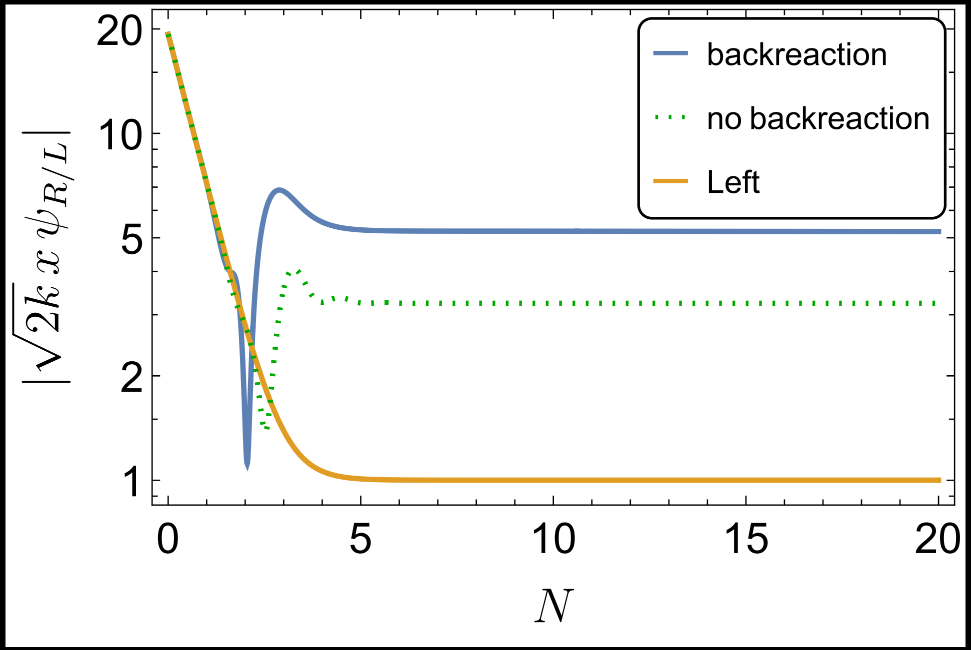
$\mathrm{SU}(2) \longleftrightarrow$




[OI, E. I. Sfakianakis, R. Sharma, A. Brandenburg, 2023]

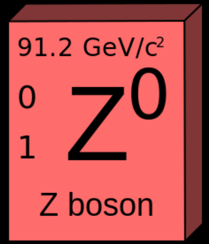


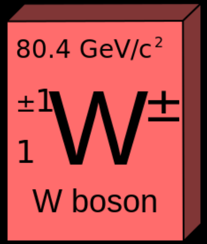




$$W_0^a = a(Y_a + \partial_a Y)\,,$$

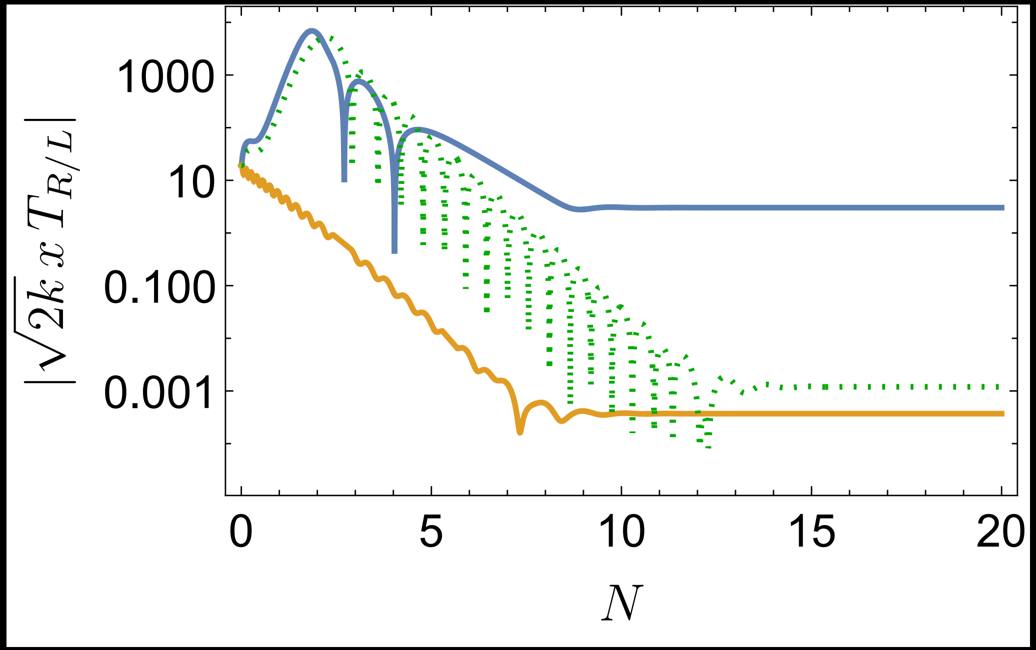
$$W_i^a = a\left[(Q + \delta Q)\,\delta_{ai} + \partial_i\,(M_a + \partial_a M) + \epsilon_{iac}\,(U_c + \partial_c U) + t_{ia}\right]$$

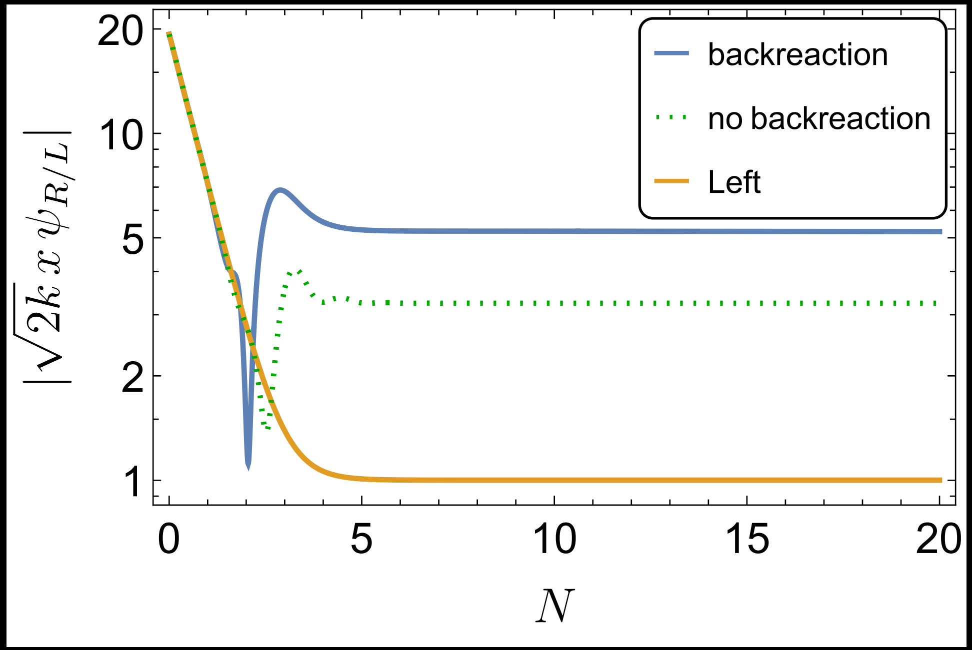
$\mathrm{SU}(2) \longleftrightarrow$




[OI, E. I. Sfakianakis, R. Sharma, A. Brandenburg, 2023]




$$A_\mu = W^3_\mu \sin\theta_W + B_\mu \cos\theta_W$$

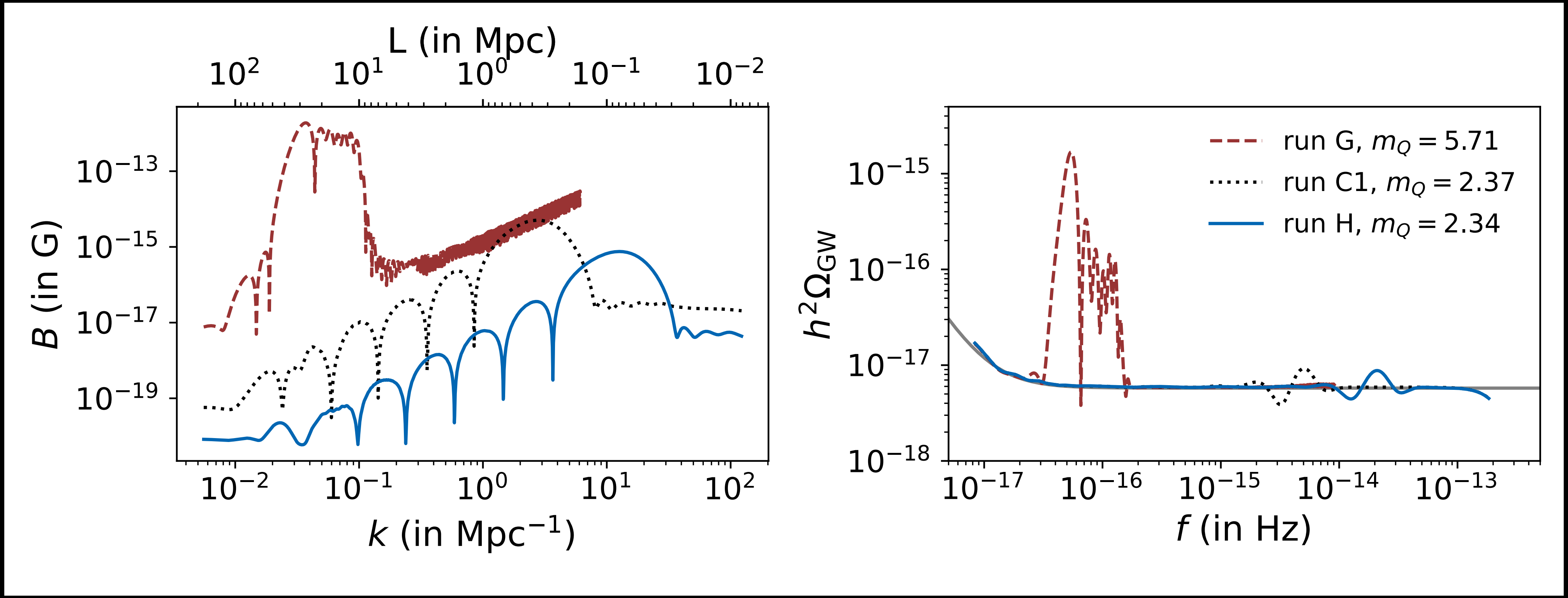
$$Z_\mu = W^3_\mu \cos\theta_W - B_\mu \sin\theta_W$$

$$|A_i|^2 = \frac{1}{4}\left(|T_L|^2 + |T_R|^2\right)$$

# Magnetic field energy spectrum

[A. Brandenburg, OI, E. I. Sfakianakis, R. Sharma, 2024]

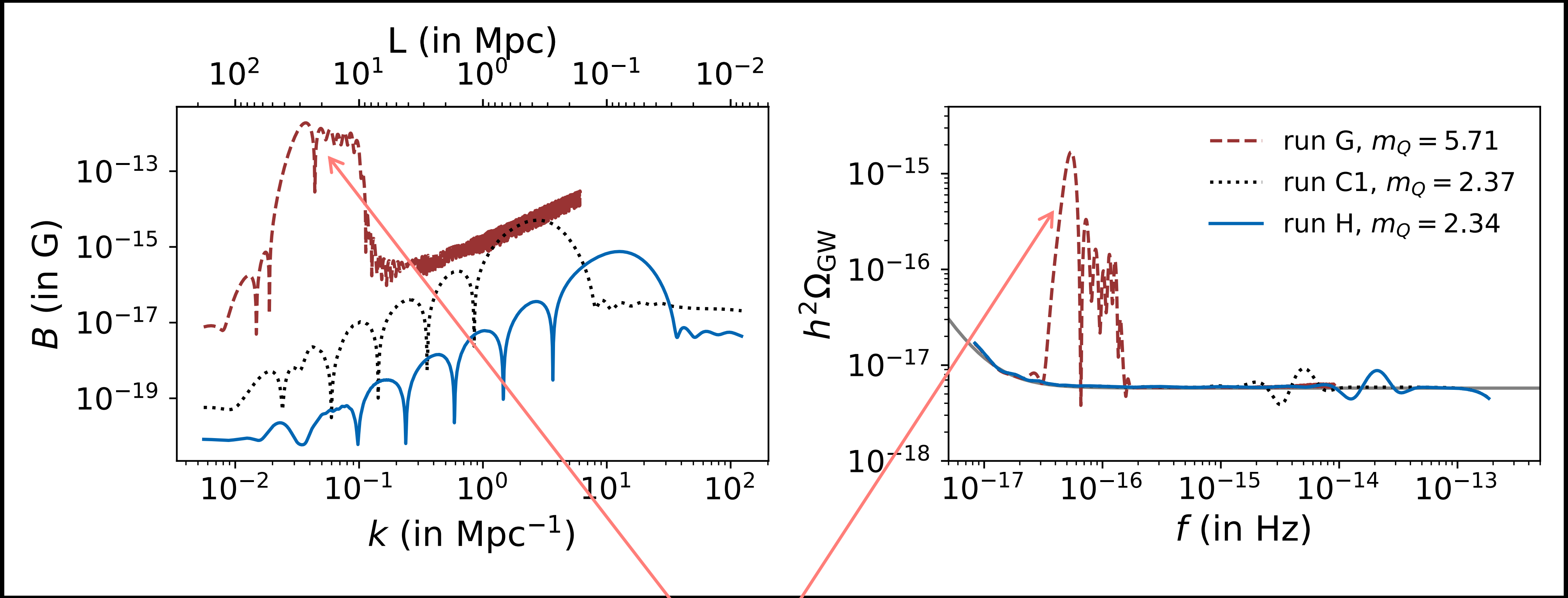
$$\Delta_{\mathrm{B}}(k) = \frac{1}{(2\pi)^2}\frac{k^5}{a^4}|A_i|^2 \qquad\qquad B \approx \sqrt{2\Delta_{\mathrm{B}}(k)\big|_0}$$



# Magnetic field energy spectrum

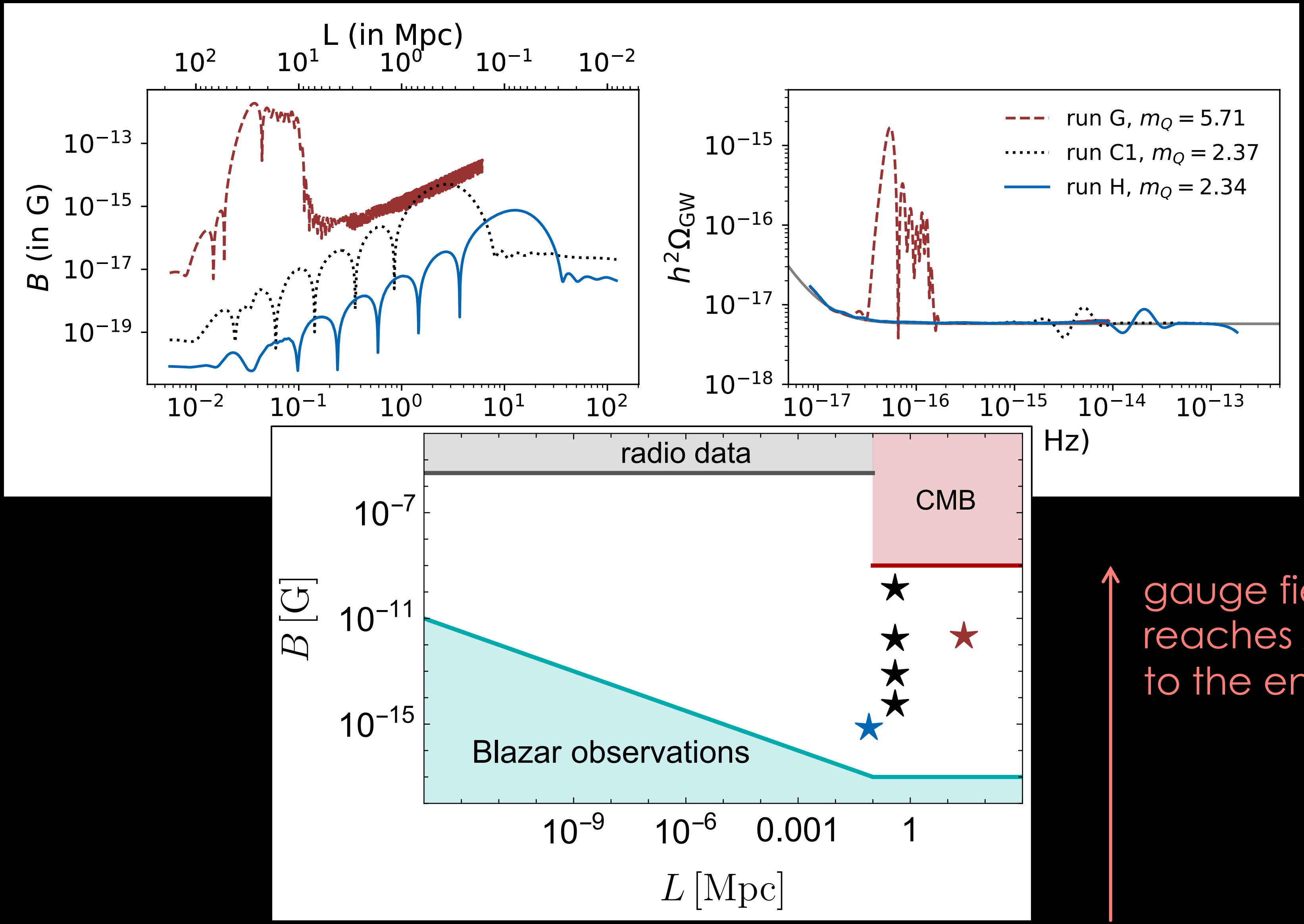
[A. Brandenburg, OI, E. I. Sfakianakis, R. Sharma, 2024]

$$\Delta_{\mathrm{B}}(k) = \frac{1}{(2\pi)^2}\frac{k^5}{a^4}|A_i|^2 \qquad B \approx \sqrt{2\Delta_{\mathrm{B}}(k)\big|_0}$$




Correlated signal from primordial magnetic fields and gravitational waves

# Magnetic field energy spectrum



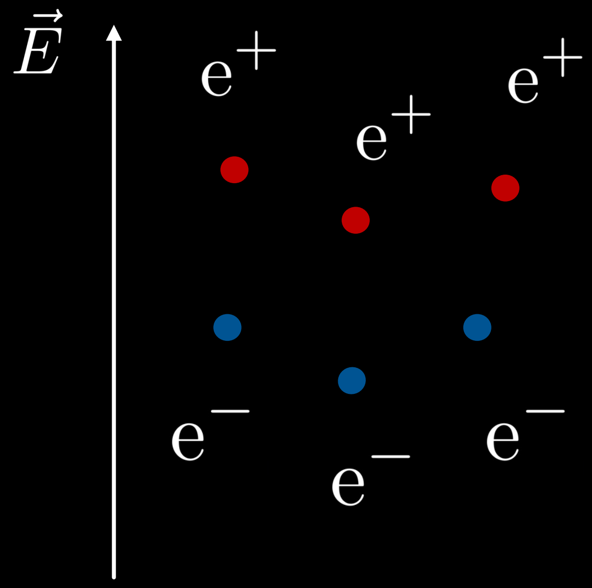

gauge field vev reaches zero close to the end of inflation

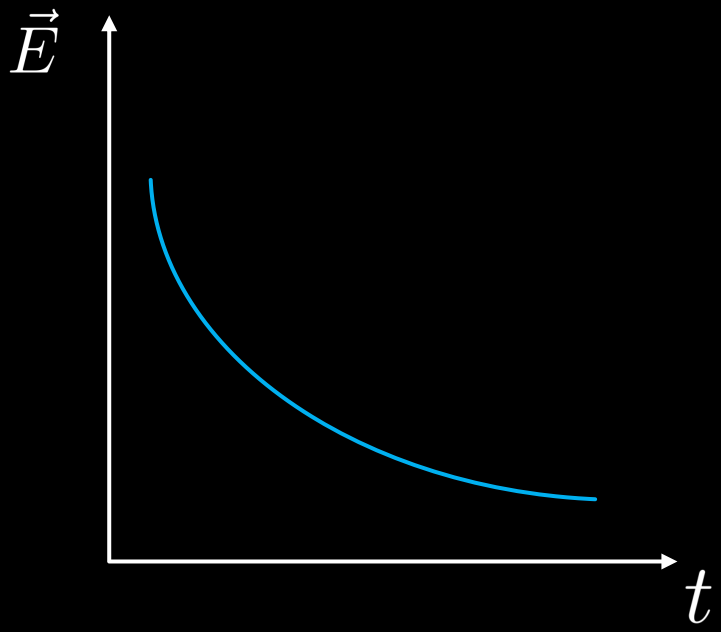
larger instability

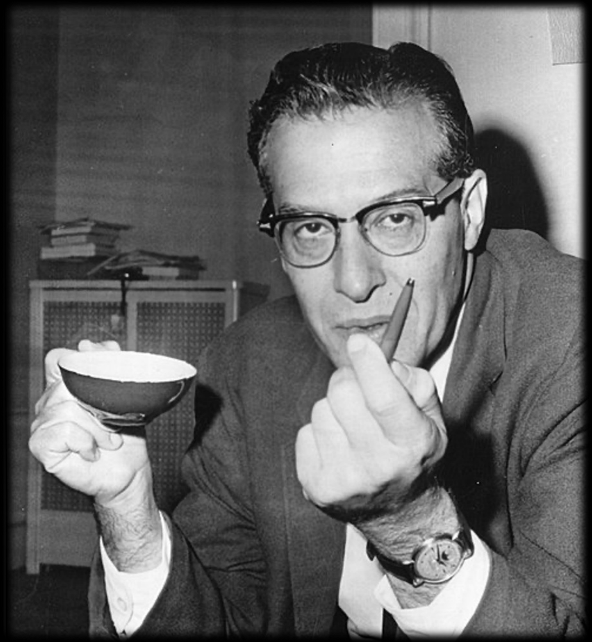
[A. Brandenburg, OI, E. I. Sfakianakis, R. Sharma, 2024]

# What about the backreaction from electric currents?

# Schwinger effect



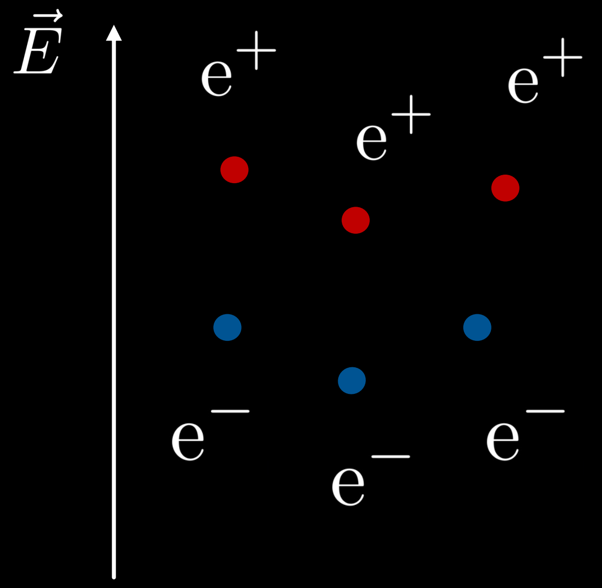



[Sauter, 1931,
Heisenberg and Euler, 1936,
Schwinger, 1951]

$$E_c \sim 10^{18}\ \mathrm{V/m}$$

# Created particles generate the induced Schwinger current

In an expanding universe:




electric conductivity

$$\vec{J} = \sigma_E \vec{E}$$

$$\vec{J} = \sigma_E \vec{E} + \sigma_B \vec{B}$$

[Kobayashi et al, 2014]
[Bavarsad et al.'18]
[Gorbar et al, 2021]
[Domcke et al, 2018; 2020]
[Fujita et al, 2022]
[von Eckardstein et al, 2025]

# Axion-U(1) inflation

$$S = \int d^4x \sqrt{-g} \left[ -\frac{1}{2}\partial_\mu \phi \partial^\mu \phi - V(\phi) - \frac{1}{4} F_{\mu\nu} F^{\mu\nu} - \frac{\alpha}{4f} \phi F_{\mu\nu} \tilde{F}^{\mu\nu} \right]$$

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

Abelian gauge field

[K. Freese, J. A. Frieman, and A. V. Olinto, 1990]
[M. M. Anber and L. Sorbo, 2009]
...
[A. Caravano, E. Komatsu, K.D. Lozanov and J. Weller, 2022]
[D.G. Figueroa, J. Lizarraga, A. Urio and J. Urrestilla, 2023]
[R. Sharma, A. Brandenburg, K. Subramanian, A. Vikman, 2024]

CosmoLattice

The Pencil Code
a high-order finite-difference code for compressible MHD

# Axion-U(1) inflation: Schwinger effect

$$S = \int d^4x \sqrt{-g} \left[ -\frac{1}{2}\partial_\mu\phi\partial^\mu\phi - V(\phi) - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{\alpha}{4f}\phi F_{\mu\nu}\tilde{F}^{\mu\nu} + \mathcal{L}_{\rm ch} \right]$$

$$\partial_\tau^2\phi + 2\mathcal{H}\partial_\tau\phi - \boldsymbol{\nabla}^2\phi + a^2\frac{dV}{d\phi} = \frac{\alpha}{a^2 f}\boldsymbol{E}\cdot\boldsymbol{B},$$

$$\partial_\tau\boldsymbol{E} - \mathrm{rot}\,\boldsymbol{B} + \frac{\alpha}{f}\left(\partial_\tau\phi\boldsymbol{B} + \boldsymbol{\nabla}\phi\times\boldsymbol{E}\right) + \boldsymbol{J} = 0,$$

$$\boldsymbol{\nabla}\cdot\boldsymbol{E} = -\frac{\alpha}{f}\boldsymbol{\nabla}\phi\cdot\boldsymbol{B}, \quad \boldsymbol{\nabla}\cdot\boldsymbol{B} = 0,$$

$$\partial_\tau\boldsymbol{B} + \mathrm{rot}\,\boldsymbol{E} = 0,$$

$$\mathcal{H}^2 = \frac{8\pi}{3m_{\rm Pl}^2}a^2\left(\rho_\phi + \rho_E + \rho_B + \rho_\chi\right),$$

**The Pencil Code**
a high-order finite-difference code for compressible MHD

# Axion-U(1) inflation: Schwinger effect

$$S = \int d^4x \sqrt{-g} \left[ -\frac{1}{2}\partial_\mu\phi\partial^\mu\phi - V(\phi) - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{\alpha}{4f}\phi F_{\mu\nu}\tilde{F}^{\mu\nu} + \mathcal{L}_{\rm ch} \right]$$

Effective current description of the Schwinger effect

$$J = \frac{(e|Q|)^3}{6\pi^2\mathcal{H}} E|B| \coth\left(\frac{\pi|B|}{E}\right) e^{-\frac{\pi m^2 a^2}{e|Q|E}}$$

[Kobayashi et al, 2014]
[Bavarsad et al.'18]
[Gorbar et al, 2021]
[Domcke et al, 2018; 2020]
[Fujita et al, 2022]
[von Eckardstein et al, 2025]

Inhomogeneous 3D lattcie simulations using

**The Pencil Code**
a high-order finite-difference code for compressible MHD

# Axion-U(1) inflation: Schwinger effect

$$S = \int d^4x\sqrt{-g}\left[-\frac{1}{2}\partial_\mu\phi\partial^\mu\phi - V(\phi) - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{\alpha}{4f}\phi F_{\mu\nu}\tilde{F}^{\mu\nu} + \mathcal{L}_{\rm ch}\right]$$

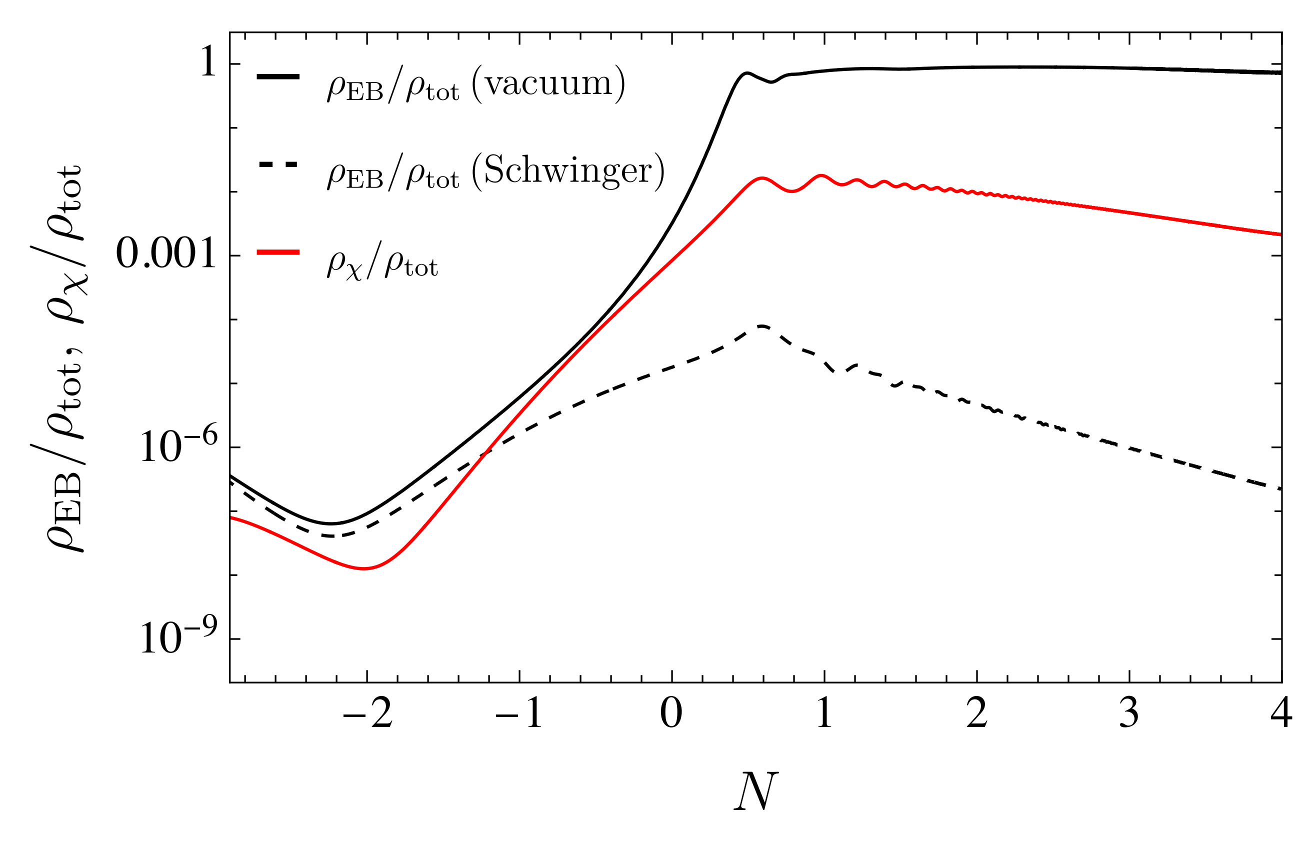
$$\dot{\boldsymbol{E}} + (2H + \sigma_E)\boldsymbol{E} - \frac{1}{a}\mathrm{rot}\mathrm{B} + \left(\frac{\alpha}{\mathrm{f}}\dot{\phi} + \sigma_{\mathrm{B}}\right)\mathrm{B} = 0$$

$\sigma_E$: extra friction

$\sigma_{\mathrm{B}}$: dampens the gauge field production

[Kobayashi et al, 2014]
[Bavarsad et al.'18]
[Gorbar et al, 2021]
[Domcke et al, 2018; 2020]
[Fujita et al, 2022]
[von Eckardstein et al, 2025]

$$\partial_\tau \rho_\chi + 4\mathcal{H}\rho_\chi = \frac{1}{a^3}\left(\langle\sigma_E\rangle\,\langle \boldsymbol{E}^2\rangle + \langle\sigma_B\rangle\langle \boldsymbol{E}\cdot\boldsymbol{B}\rangle\right)$$

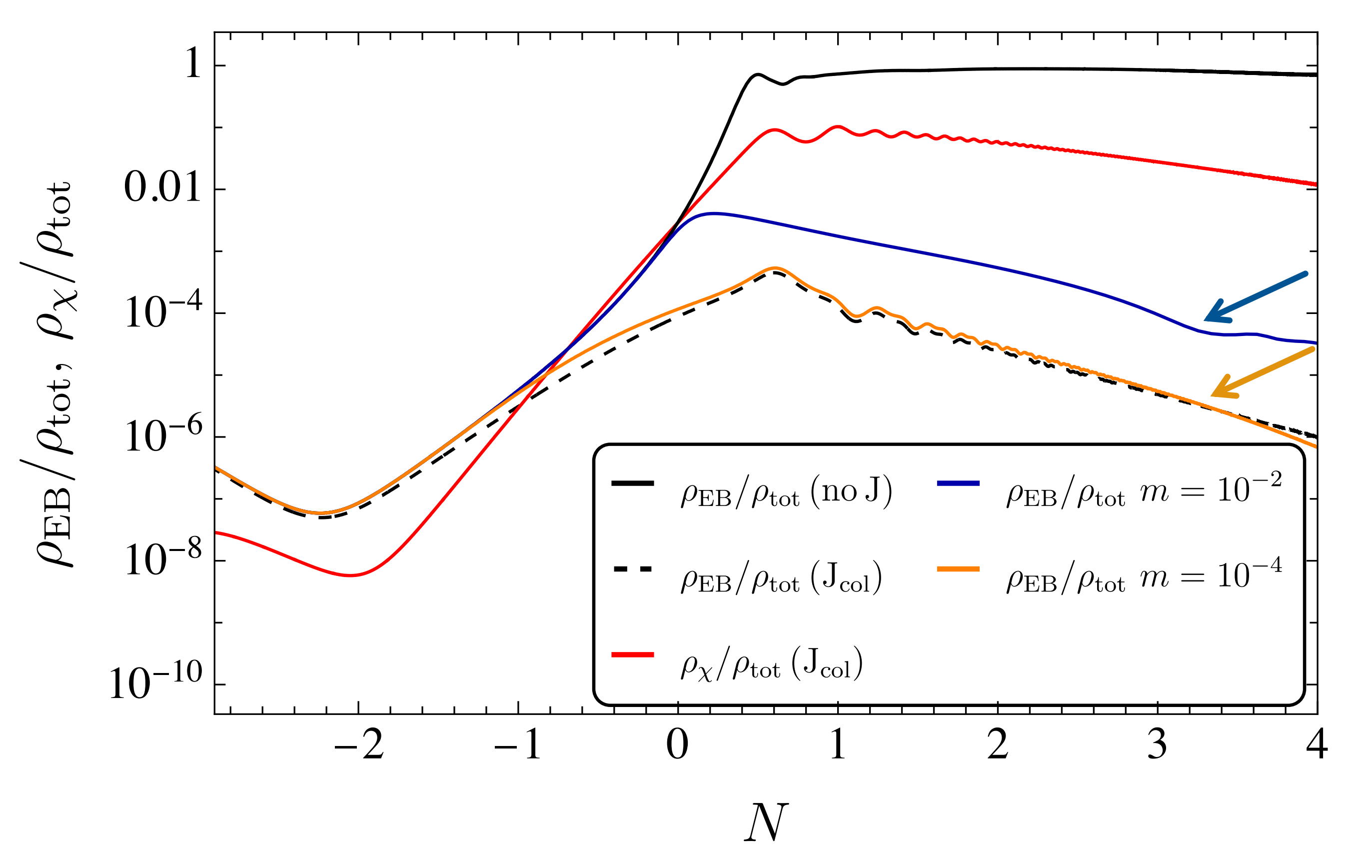



Schwinger suppression challenges gauge preheating!

[OI, A. Brandenburg, E. Sfakianakis, 2025]

# Heavy fermion effects

$$J = \frac{(e|Q|)^3}{6\pi^2 \mathcal{H}} E|B| \coth\left(\frac{\pi|B|}{E}\right) e^{-\frac{\pi m^2 a^2}{e|Q|E}}$$



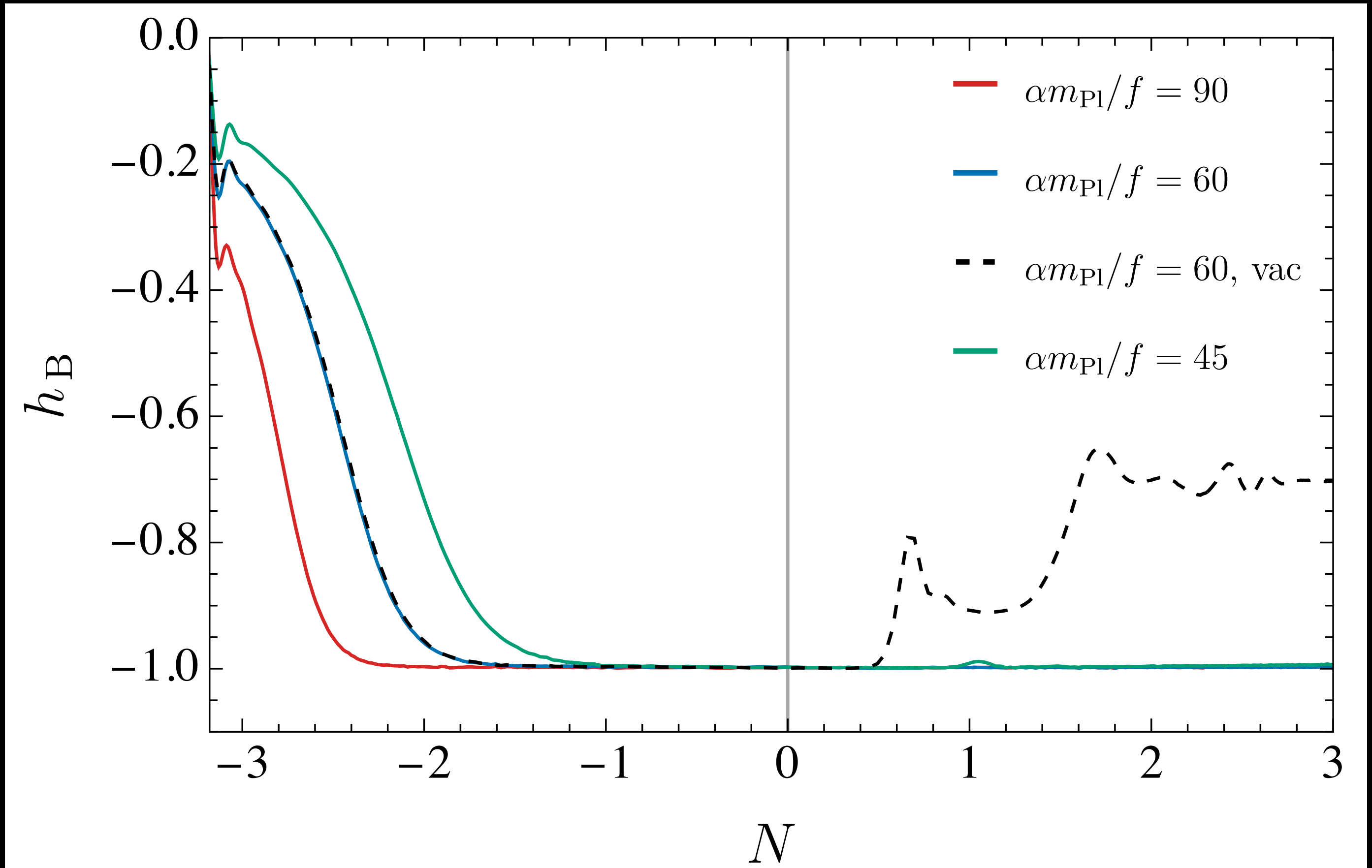

[OI, A. Brandenburg, E. Sfakianakis, 2025]

# Consequences for magnetogenesis

The Schwinger effect maintains magnetic fields to remain fully helical

The magnetic helicity

$$h_{\rm B} = \frac{\langle A \cdot B \rangle}{(L_c \langle B^2 \rangle)}$$

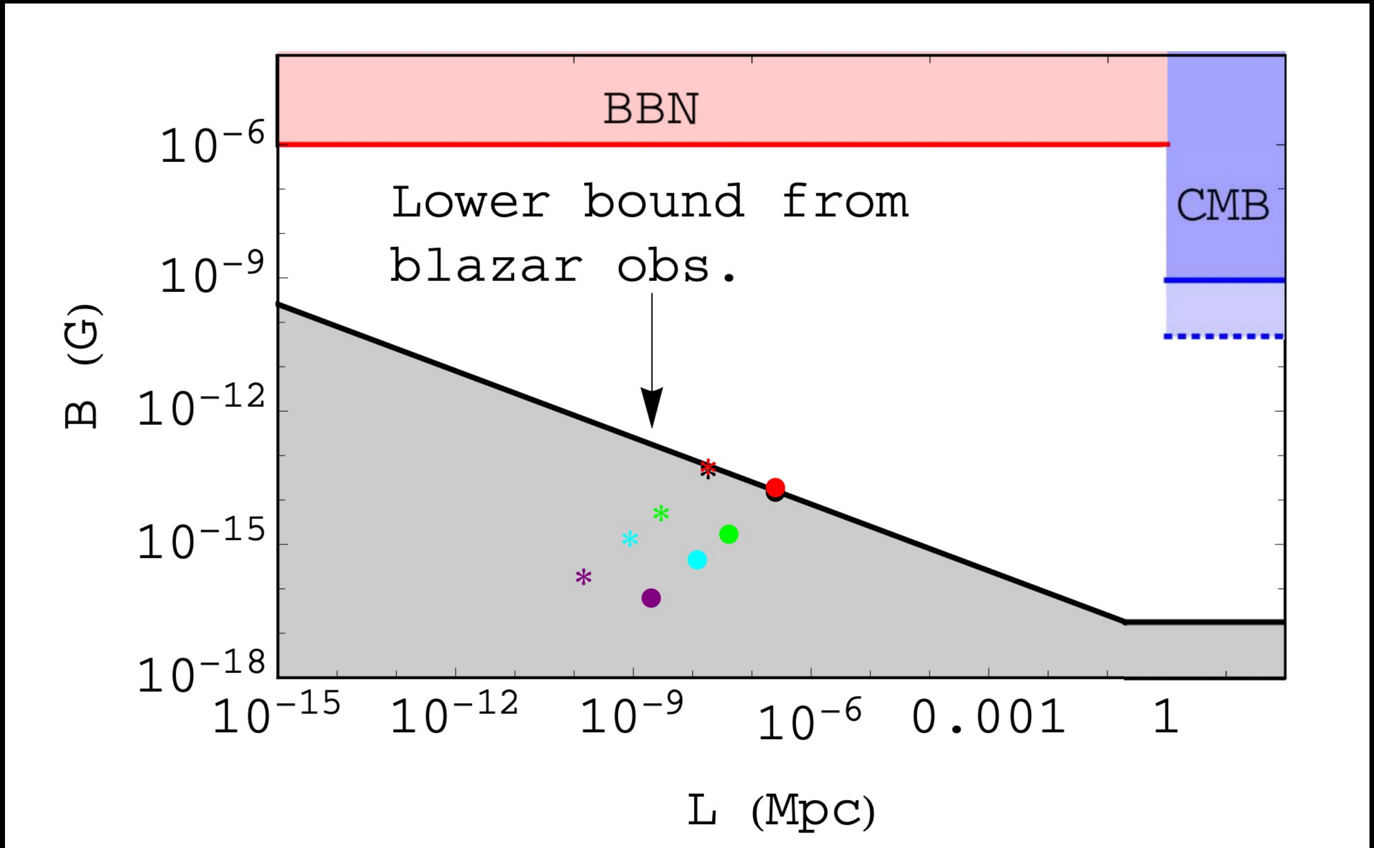



[OI, A. Brandenburg, E. Sfakianakis, 2025]

# Consequences for magnetogenesis

[R. Sharma, A. Brandenburg, K. Subramanian, A. Vikman, 2024]

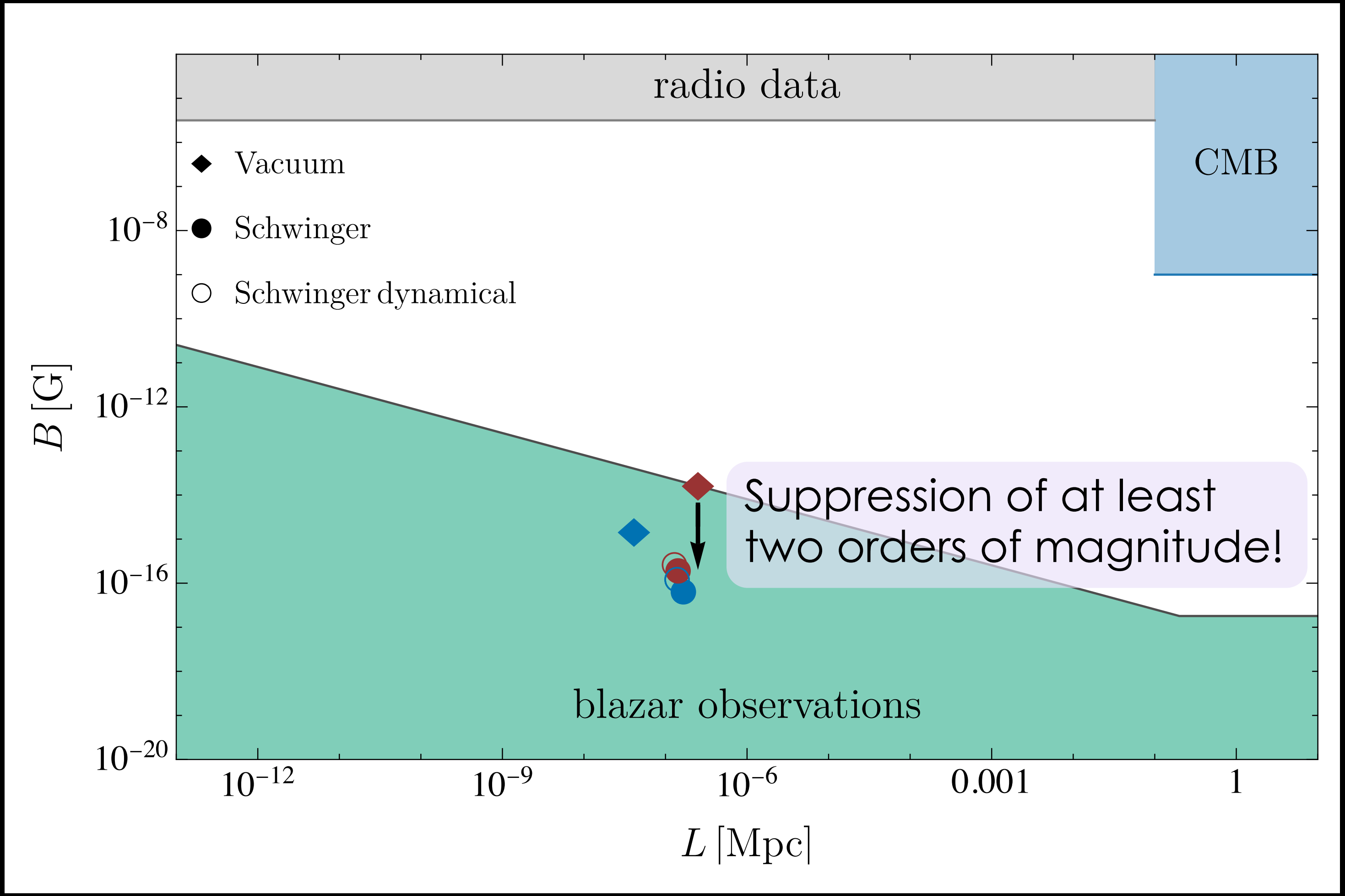
Without the Schwinger effect




$$\alpha m_{\mathrm{Pl}}/f = 35,\ 50,\ 60, 75,\ 90$$

# Consequences for magnetogenesis

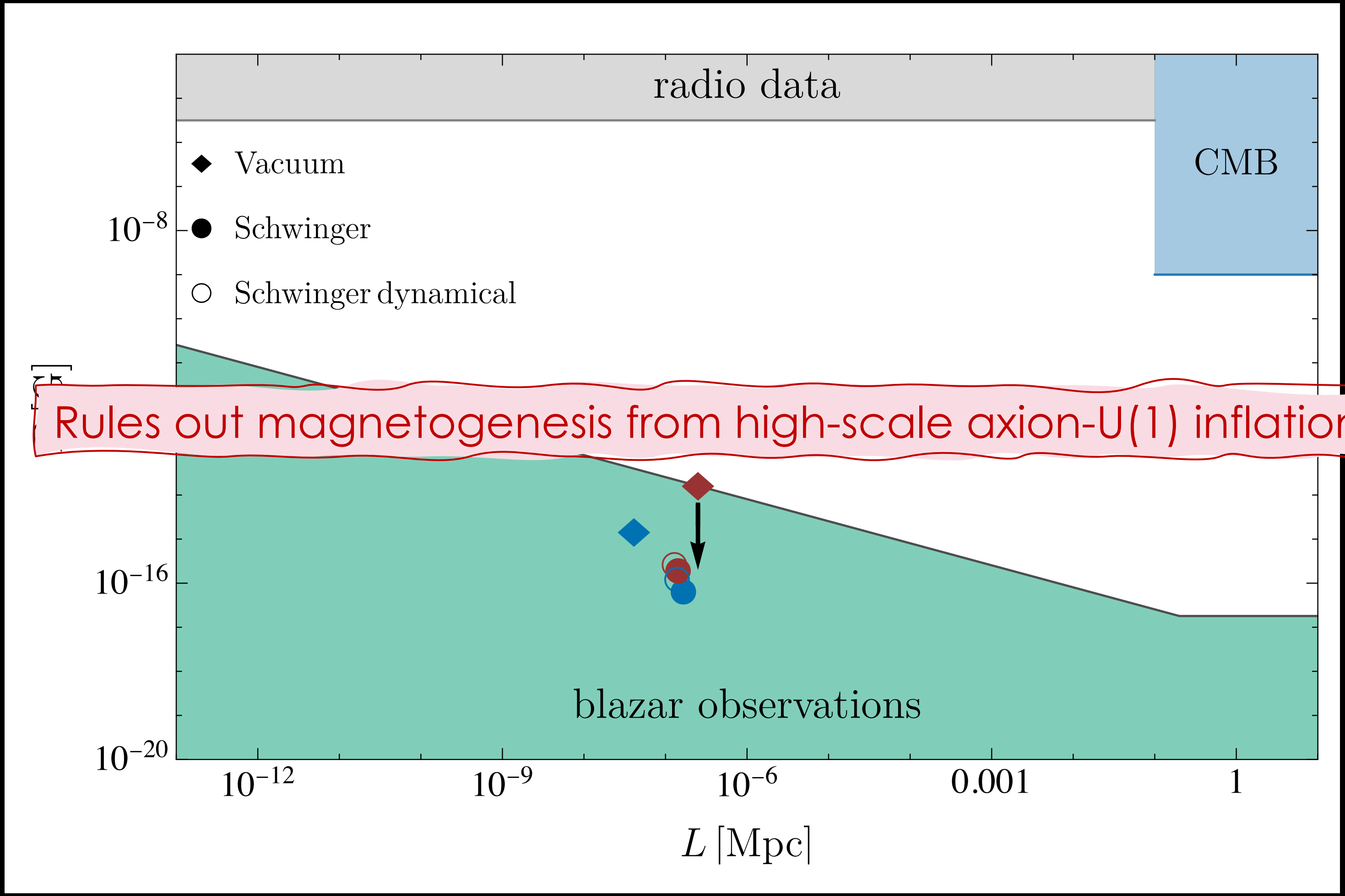
With the Schwinger effect




[OI, A. Brandenburg, E. Sfakianakis, 2025]

# Consequences for magnetogenesis

With the Schwinger effect




Rules out magnetogenesis from high-scale axion-U(1) inflation

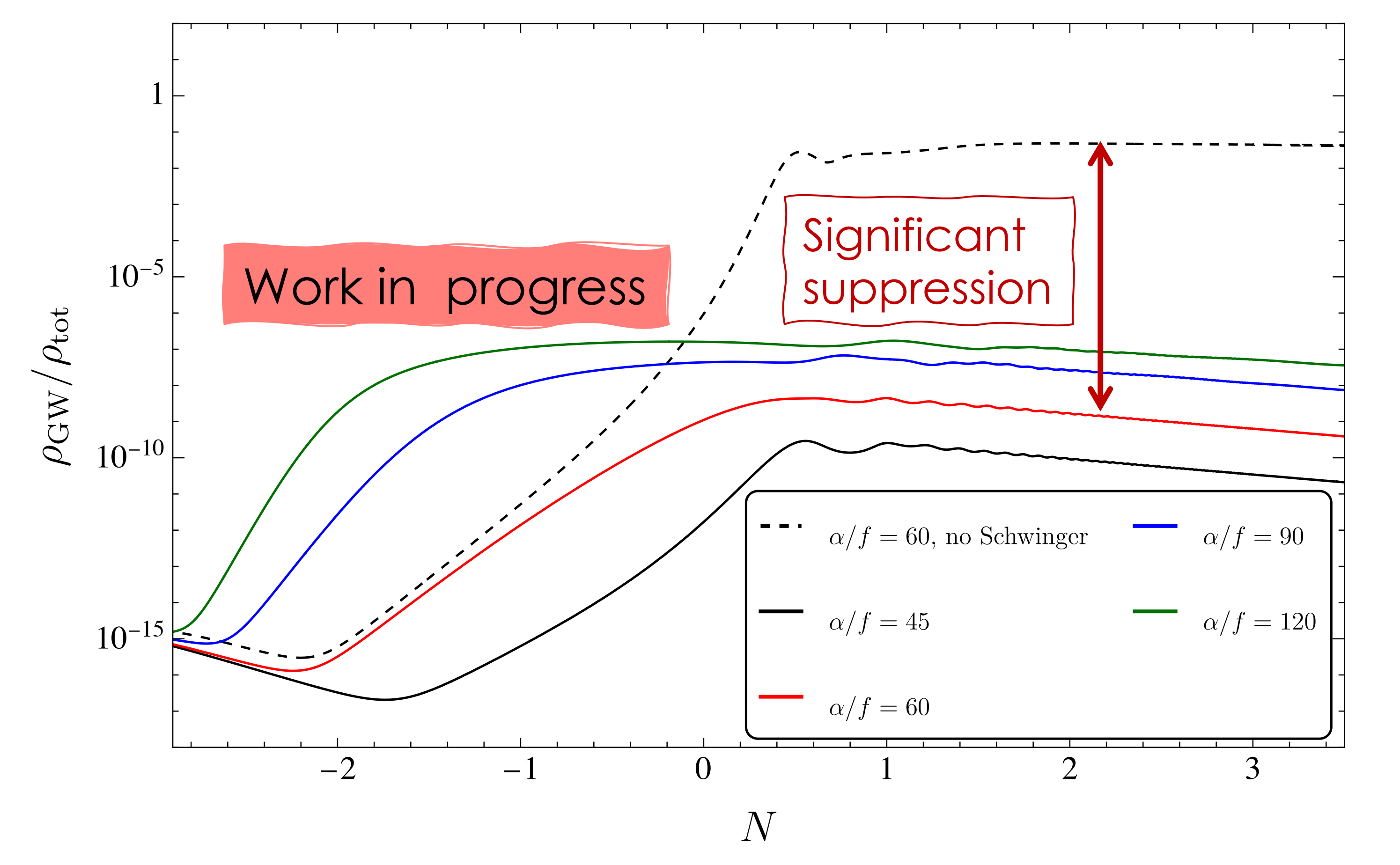
[OI, A. Brandenburg, E. Sfakianakis, 2025]

# How does the Schwinger effect influence gravitational wave production?

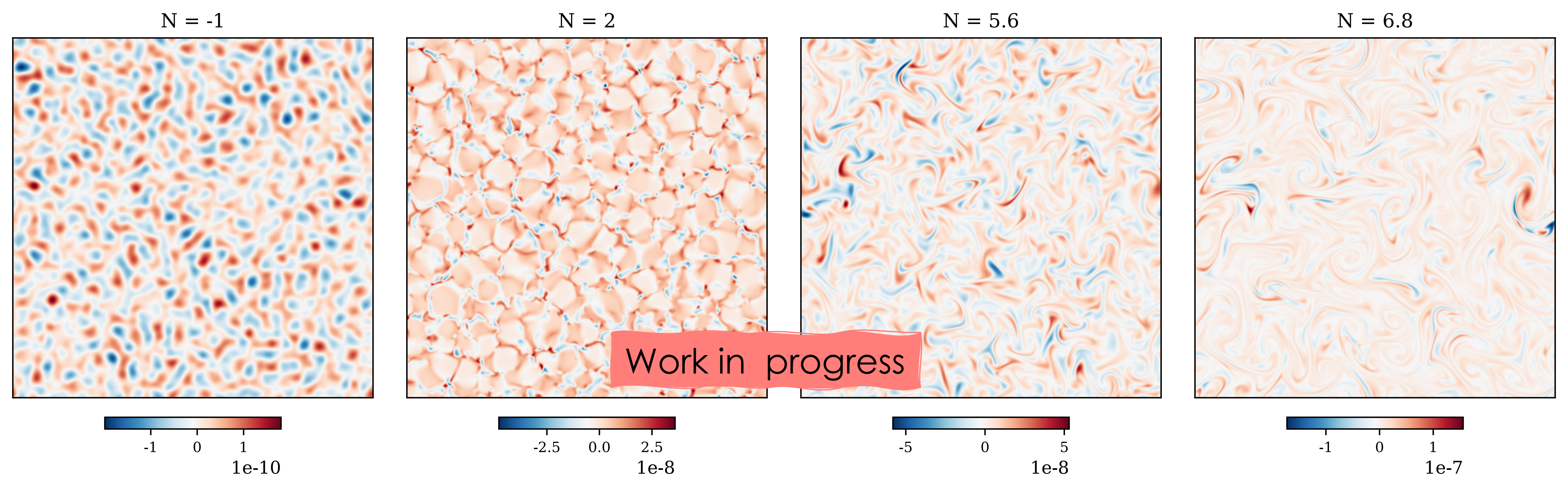
# Gravitational waves with the Schwinger effect

**The Pencil Code**

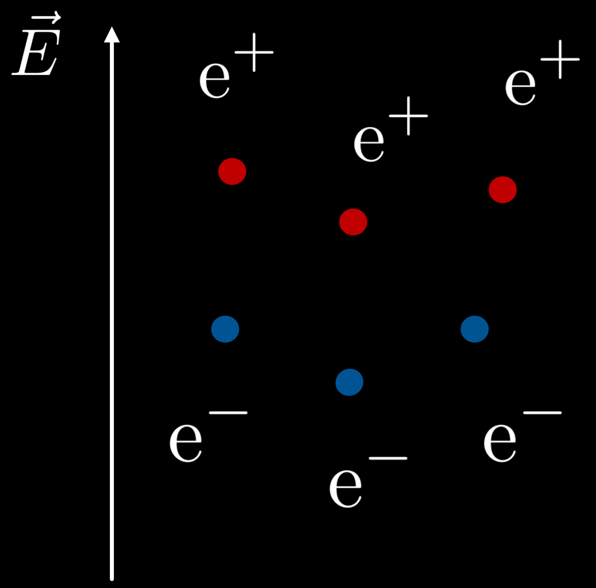
a high-order finite-difference code for compressible MHD

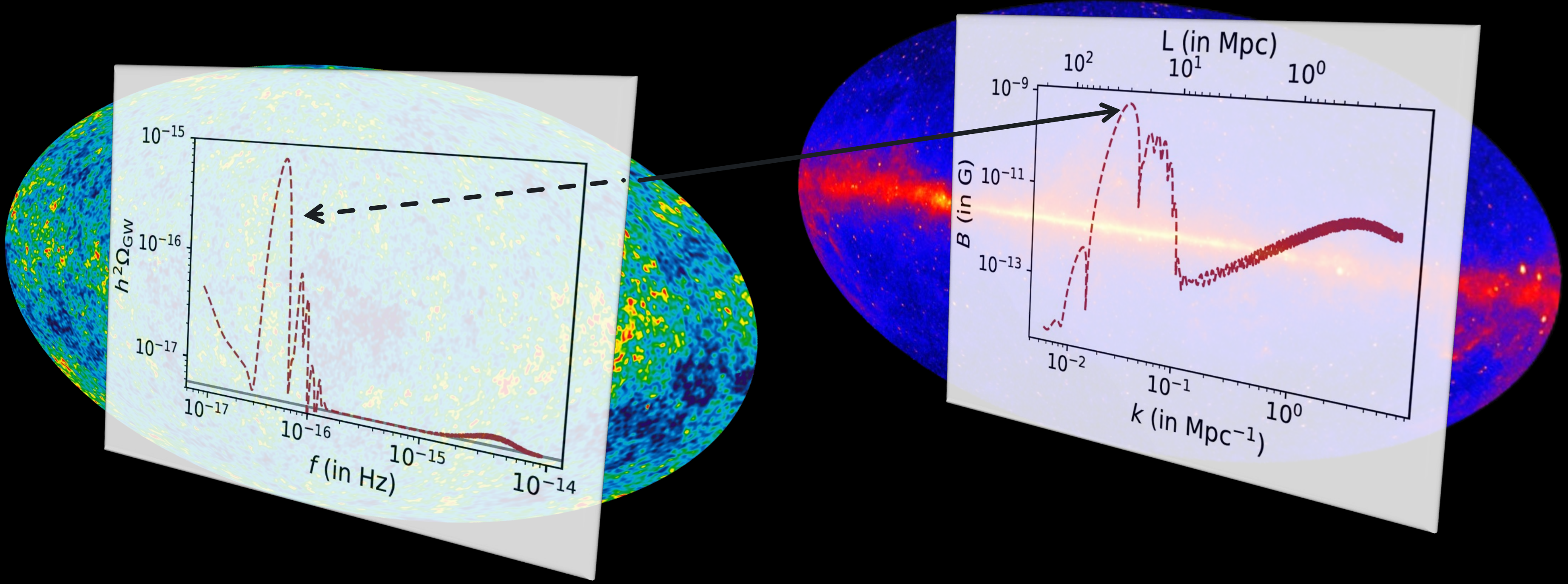


# From inflation to MHD



# Take-home message




- SU(2): Backreaction effects during axion-SU(2) inflation lead to a novel attractor solution and produce correlated gravitational wave and primordial magnetic field signals.
- U(1): Schwinger effect can strongly quench gauge-field growth, challenging axion-U(1) magnetogenesis, preheating and GW production.

Contact | Press | Publications

About MIAPbP Activities Registration For Visitors Propose

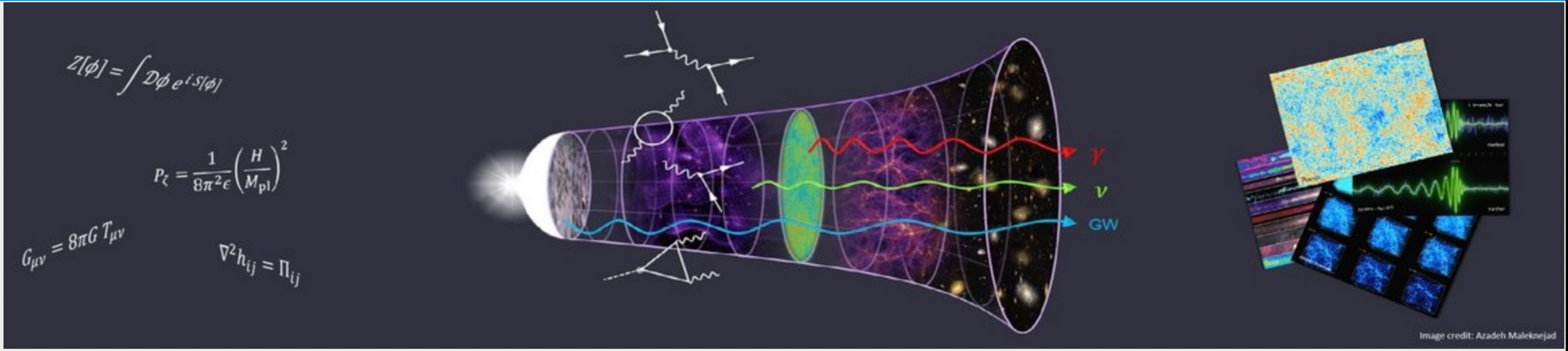



Image Credit: Azadeh Maleknejad

# QUANTUM FIELDS TO COSMIC SIGNATURES: PROBING PARTICLE PRODUCTION IN THE EARLY UNIVERSE

05 - 30 April 2027

Angelo Caravano, Azadeh Maleknejad, Oksana Iarygina, Kaloian D. Lozanov, Eiichiro Komatsu

**Week 1 – Theory and Phenomenology**

Inflation, Baryogenesis, Dark matter, Primordial black holes

**Week 2 – Numerical Techniques and Simulations**

Lattice methods, Non-perturbative dynamics, Computational frameworks

**Week 3* – Topical Workshop and Focused Panels**

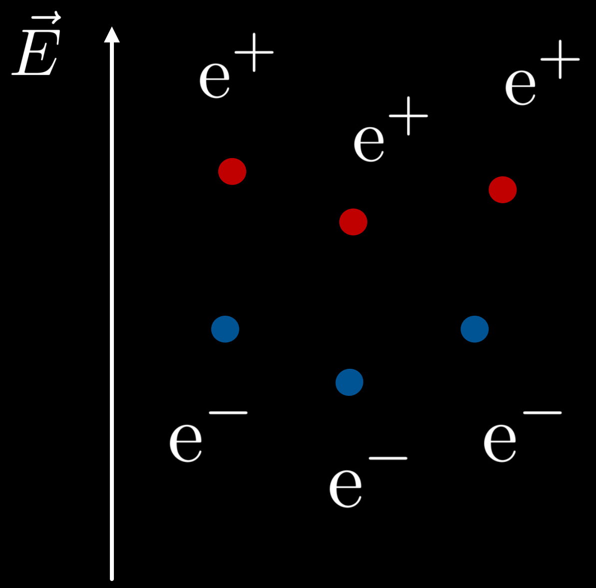
Invited talks , Cross-disciplinary discussions, Emerging directions

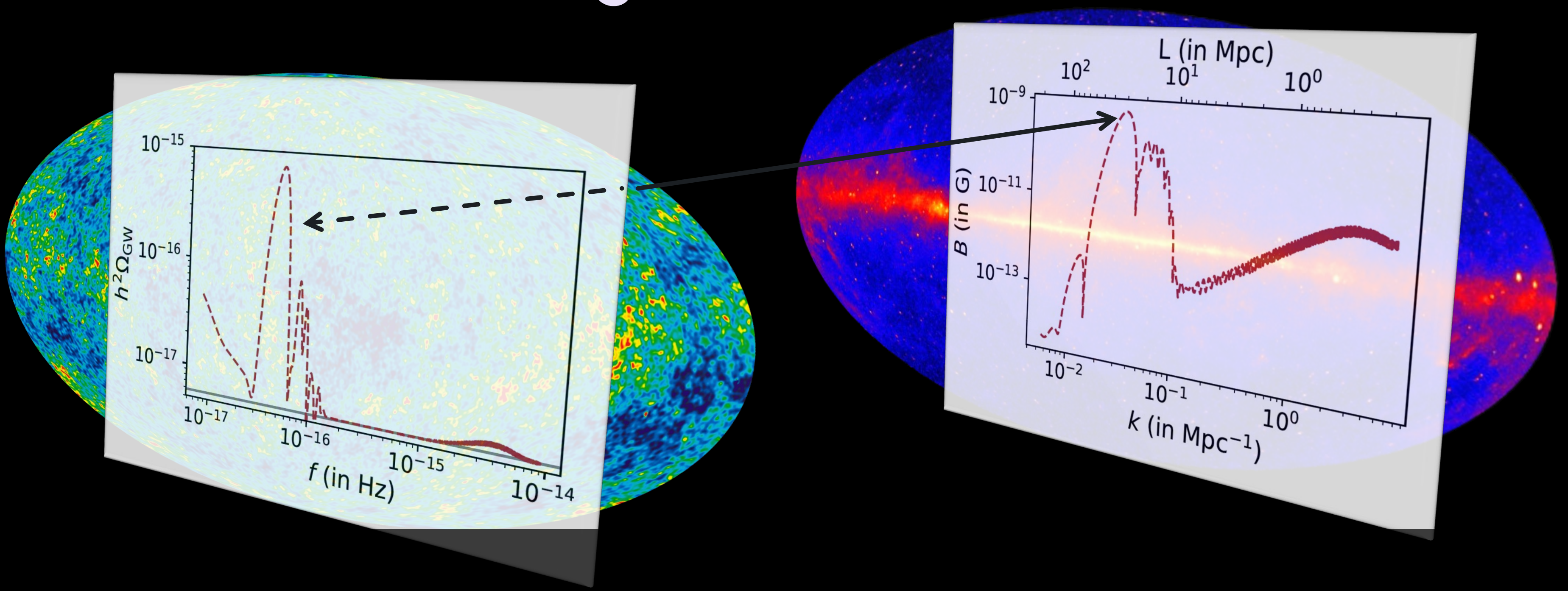
**Week 4 – Observational and Experimental Probes**

Gravitational waves, Neutrinos, Primordial magnetic fields, Multi-messengers

Registration deadline:
26 July 2026

# Thank you!




- SU(2): Backreaction effects during axion-SU(2) inflation lead to a novel attractor solution and produce correlated gravitational wave and primordial magnetic field signals.
- U(1): Schwinger effect can strongly quench gauge-field growth, challenging axion-U(1) magnetogenesis, preheating and GW production.