New perspectives on baryogenesis

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RICE

Many thanks

Many thanks to our conference organizers and local hosts!

Many thanks to my baryogenesis co-conveners: Daniele Teresi & Sacha Davidson

Many thanks to our baryogenesis parallel speakers:

Monday:

Neutrino Option Leptogenesis	*Jessica Turner*
Grey Room 2, IFT	16:40 - 17:00
Type-I Seesaw as the Common Origin of Neutrino Mass, Baryon Asymmetry, and the Electroweak Scale	*Kai Ruven Schmitz*
Preheating confronts leptogenesis	*Djuna Croon*
Grey Room 2, IFT	17:20 - 17:40

Tuesday:

Baryogenesis from Primordial Helical Hypermagnetic Fields	*Kohei Kamada*
Red Room, IFT	17:10 - 17:30
The baryon asymmetry from a composite Higgs	*Oleksii Matsedonskyi*
Red Room, IFT	17:30 - 17:50
High Scale Electroweak Baryogenesis	*Dr Iason Baldes*
Red Room, IFT	17:50 - 18:10

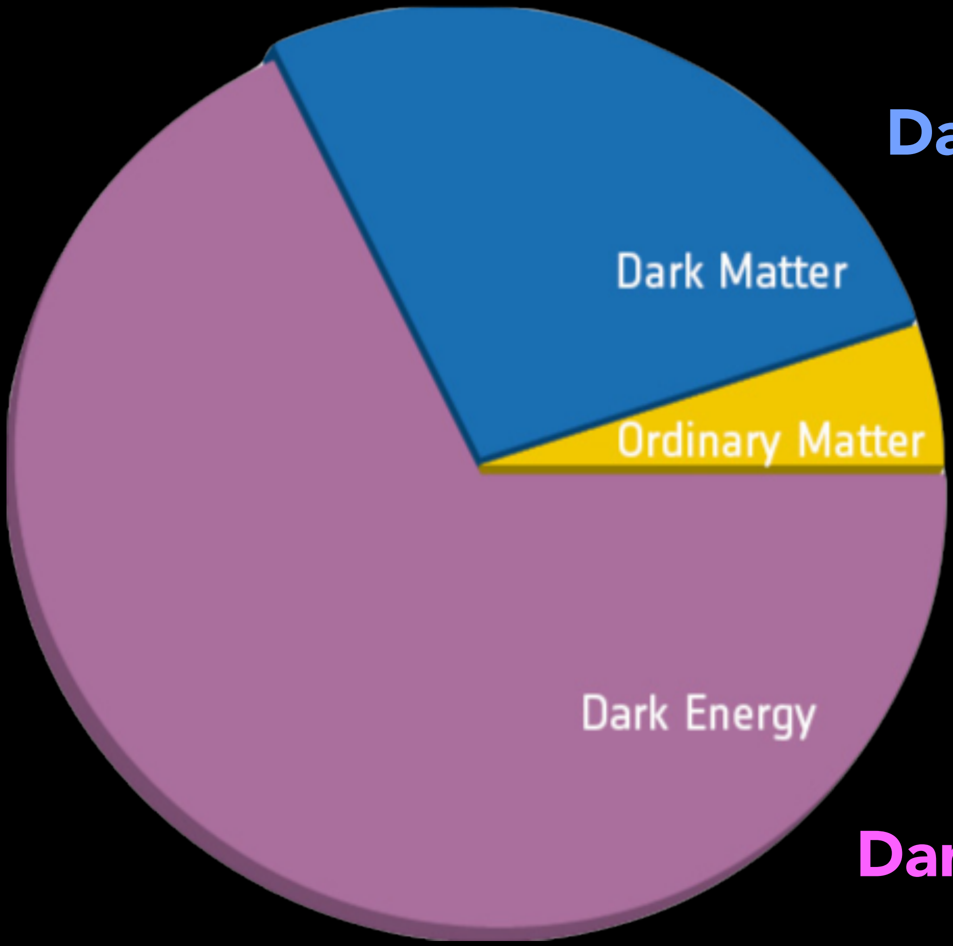
Wednesday:

Parameter space of baryogenesis in the νMSM	*Inar Timiryasov*
Grey Room 2, IFT	14:15 - 14:35
Low-scale leptogenesis with three heavy neutrinos	*Juraj Klaric*
Grey Room 2, IFT	14:35 - 14:55
Leptogenesis in the Scotogenic model	*Vedran Brdar*
Grey Room 2, IFT	14:55 - 15:15

Thursday:

Baryogenesis and Dark Matter from B Mesons	*Miguel Escudero*
Grey Room 2, IFT	15:40 - 16:00
All-in-one relaxion	*Jakub Scholtz*
Grey Room 2, IFT	16:00 - 16:20
Leptogenesis without Loops	*Arnab Dasgupta*
Grey Room 2, IFT	16:20 - 16:40

Why baryogenesis?



Dark Matter: what is it?

Ordinary Matter:
where does it come from?

(interesting: uniquely connected with elementary particle physics)

Dark Energy: what is it?

baryogenesis = a dynamical process that occurred in the early universe and led to the cosmological excess of matter over antimatter

Baryogenesis needs B-number violation

[*Planck* (2018)]

There is more matter than antimatter

cosmology says there are
more protons than anti-protons

$$\Omega_b h^2 \simeq 0.02230 \pm 0.00014$$

$$n_{\mathsf{B}}/s \simeq \left(0.861 \pm 0.005\right) \times 10^{-10}$$

We use baryon number to quantify the matter excess

charge assignments:

$$\mathsf{B}(\text{quark}) = +1/3$$
$$\mathsf{B}(\text{anti-q}) = -1/3$$
$$\mathsf{B}(\text{proton}) = \mathsf{B}(\text{neutron}) = +1$$
$$\mathsf{B}(\text{anti-p}) = \mathsf{B}(\text{anti-n}) = -1$$
$$\mathsf{B}(\text{mesons}) = \mathsf{B}(\text{leptons}) = 0$$

Baryogenesis needs B-number violation

$$\mathsf{B}(\text{universe}) = 0 \quad \xrightarrow{\text{baryogenesis}} \quad \mathsf{B}(\text{universe}) \neq 0$$

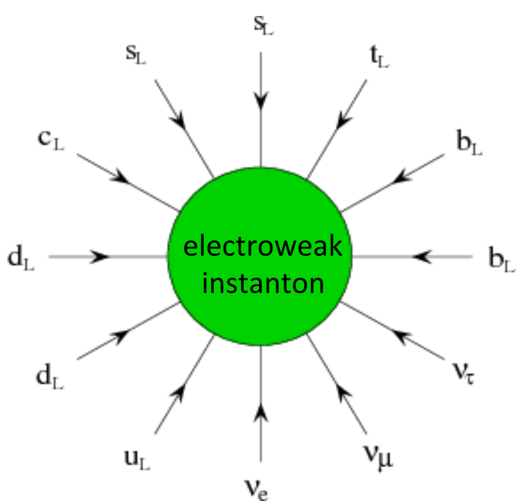
Standard Model baryon-number violation

['t Hooft (1976)]

The chiral EW interactions lead to anomalies in B and L

$$\partial_\mu j^\mu_{\mathsf{B}} = \partial_\mu j^\mu_{\mathsf{L}} = 3 \times \left(\frac{g^2}{32\pi^2} W^a_{\mu\nu} \widetilde{W}^{a\mu\nu} - \frac{g'^2}{32\pi^2} Y_{\mu\nu} \tilde{Y}^{\mu\nu} \right)$$

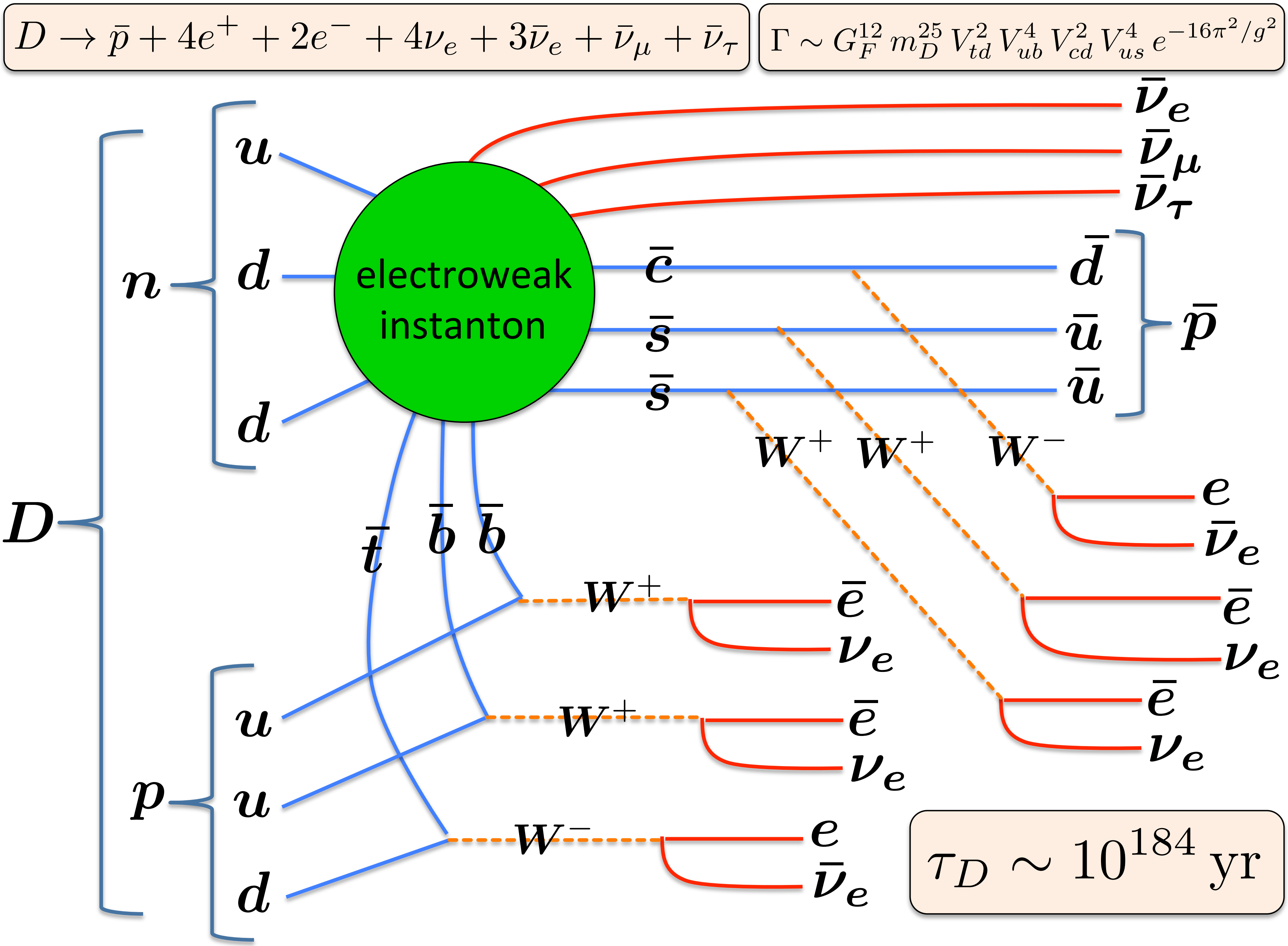
Large quantum fluctuations of W_μ^a (aka electroweak instanton) induce reactions among the quarks and leptons that violate baryon number



$$\langle W\widetilde{W} \rangle = \text{quantum}$$

$$\Delta \mathsf{B} = \Delta \mathsf{L} = \pm 3$$

The Standard Model predicts
catastrophic nuclear decay!



$D \to \bar{p} + 4e^+ + 2e^- + 4\nu_e + 3\bar{\nu}_e + \bar{\nu}_\mu + \bar{\nu}_\tau$
$\Gamma \sim G_F^{12}\, m_D^{25}\, V_{td}^2\, V_{ub}^4\, V_{cd}^2\, V_{us}^4\, e^{-16\pi^2/g^2}$
electroweak instanton
D
n
p
u
d
d
u
u
d
$\bar{\nu}_e$
$\bar{\nu}_\mu$
$\bar{\nu}_\tau$
$\bar{c}$
$\bar{s}$
$\bar{s}$
$\bar{d}$
$\bar{u}$
$\bar{u}$
$\bar{p}$
$\bar{t}$
$\bar{b}$
$\bar{b}$
W^+
W^+
W^-
W^+
W^+
W^-
e
$\bar{\nu}_e$
$\bar{e}$
ν_e
$\bar{e}$
ν_e
$\bar{e}$
ν_e
$\bar{e}$
ν_e
e
$\bar{\nu}_e$
$\tau_D \sim 10^{184}\,\mathrm{yr}$

early time <--> high temperature

10 ps	13.7 Gyr	10^{184} yr

increasing time

thermal B-violation

$$\langle W\widetilde{W}\rangle = \text{thermal}$$

today

quantum B-violation

$$\langle W\widetilde{W}\rangle = \text{quantum}$$

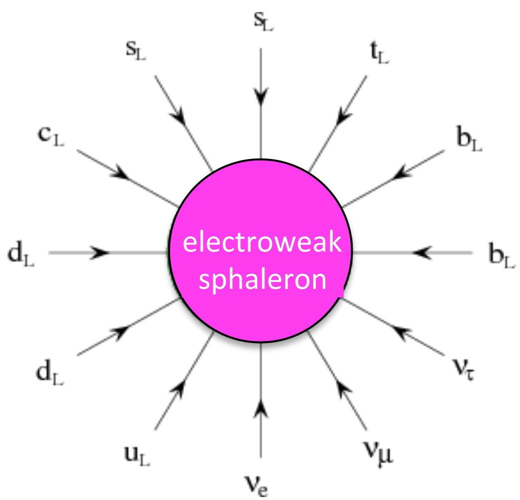
Standard Model baryon-number violation @ *high temperature*

[Klinkhamer & Manton (1984); Kuzmin, Rubakov, & Shaposhnikov (1985)]

The chiral EW interactions lead to anomalies in B and L

$$\partial_\mu j^\mu_{\mathsf{B}} = \partial_\mu j^\mu_{\mathsf{L}} = 3 \times \left(\frac{g^2}{32\pi^2} W^a_{\mu\nu} \widetilde{W}^{a\mu\nu} - \frac{g'^2}{32\pi^2} Y_{\mu\nu} \tilde{Y}^{\mu\nu} \right)$$

At high temperature large thermal fluctuations of W_μ^a (aka electroweak sphaleron) mediate unsuppressed baryon-number violation



$$\text{at } T > 100 \text{ GeV}$$

$$\langle W\widetilde{W} \rangle = \text{thermal}$$

$$\Delta \mathsf{B} = \Delta \mathsf{L} = \pm 3$$

$$\Gamma_{\mathsf{B}} \sim \alpha_{\mathrm{w}}^5 T$$

SM B-number violation plays an important role in many models of baryogenesis

outline

(1) testing electroweak baryogenesis
on the collider & cosmological frontiers

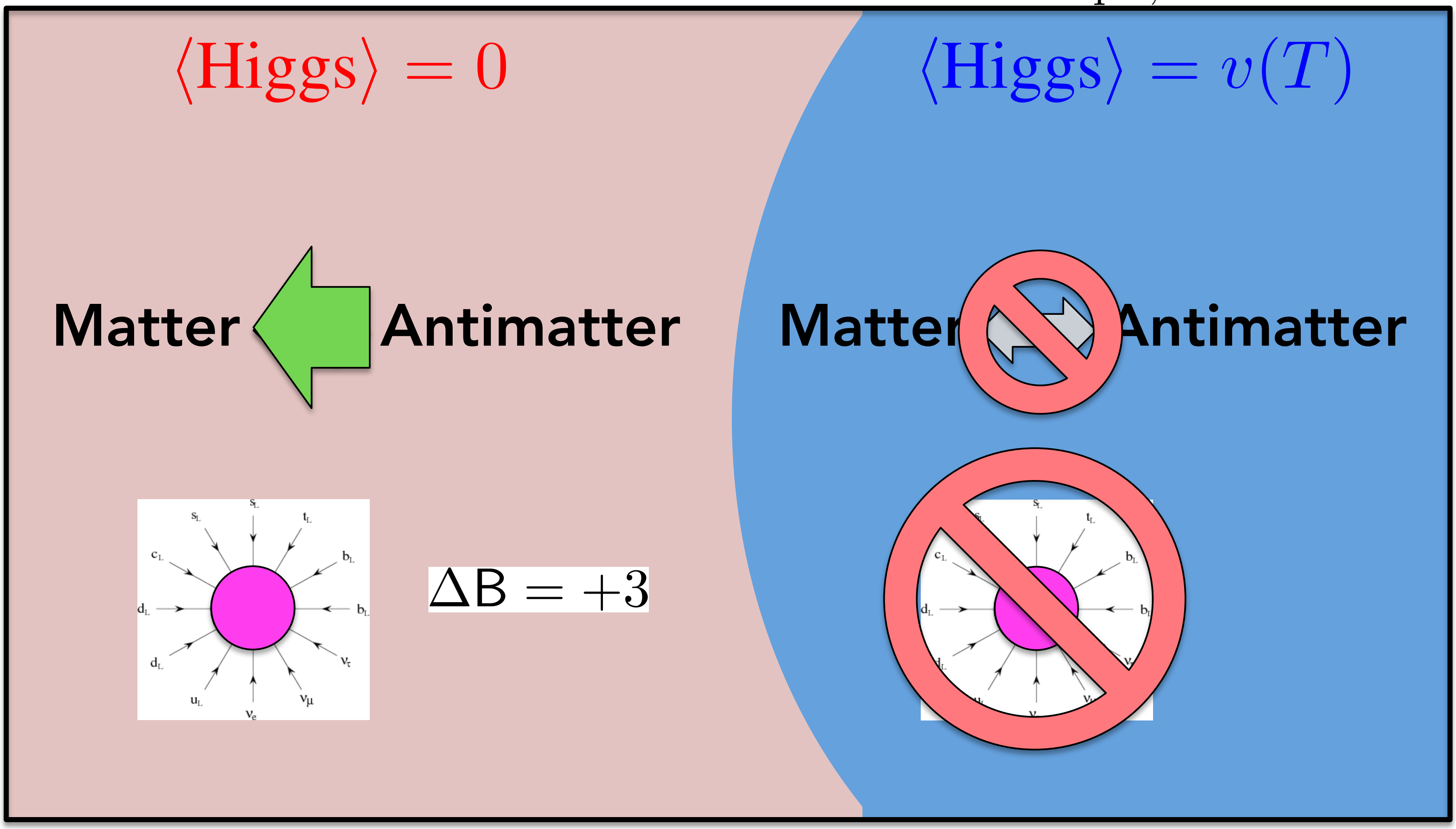
(2) a new perspective on
baryogenesis from (lepto-)bubbles

(3) baryon asymmetry
from magnetic helicity

[Kuzmin, Rubakov, & Shaposhnikov (1985); Cohen, Kaplan, & Nelson (1990)]

If the SM admits B-number violation does it admit baryogenesis?

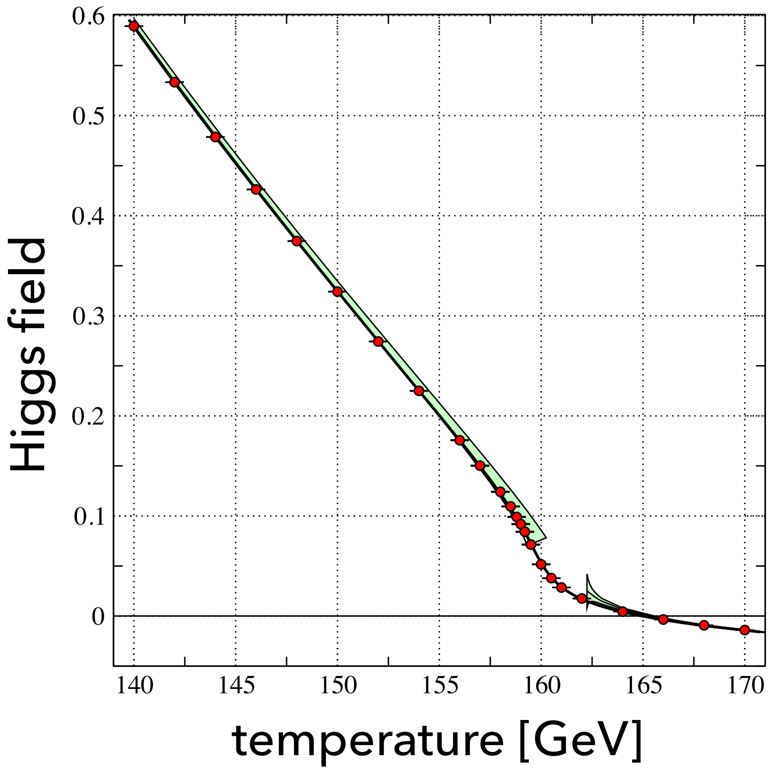
$t \approx 10$ ps , $T \approx 100$ GeV



To bubble or not to bubble? … that's the trouble!

[D'Onofrio & Rummakainen (2015)]

the SM predicts



continuous crossover
(no bubbles)

if nature allows

then new physics is
required!

Many examples of new physics for 1st order EWPT

Model	References
SM + Scalar Singlet	Espinosa & Quiros, 1993; Benson, 1993; Choi & Volkas, 1993; McDonald, 1994; Vergara, 1996; Branco, Delepine, Emmanuel-Costa, & Gonzalez, 1998; Ham, Jeong, & Oh, 2004; Ahriche, 2007; Espinosa & Quiros, 2007; Profumo, Ramsey-Musolf, & Shaughnessy, 2007; Noble & Perelstein, 2007; Espinosa, Konstandin, No, & Quiros, 2008; Ashoorioon & Konstandin, 2009; Das, Fox, Kumar, & Weiner, 2009; Espinosa, Konstandin, & Riva, 2011; Chung & AL, 2011; Wainwright, Profumo, & Ramsey-Musolf, 2012; Barger, Chung, AL, & Wang, 2012;Huang, Shu, Zhang, 2012; Katz & Perelstein, 2014; Jiang, Bian, Huang, Shu, 2015; Huang & Li 2015; Cline, Kainulainen, Tucker-Smith, 2017; Kurup & Perelstein, 2017; Chen, Kozaczuk, & Lewsis, 2017
SM + Scalar Doublet	Davies, Froggatt, Jenkins, & Moorhouse, 1994; Huber, 2006; Fromme, Huber, & Seniuch, 2006; Cline, Kainulainen, & Trott, 2011; Kozhushko & Skalozub, 2011;
SM + Scalar Triplet	Patel, Ramsey-Musolf, 2012; Patel, Ramsey-Musolf, Wise, 2013; Huang, Gu, Yin, Yu, Zhang 2016
SM + Chiral Fermions	Carena, Megevand, Quiros, Wagner, 2005
MSSM	Carena, Quiros, & Wagner, 1996; Delepine, Gerard, Gonzales Felipe, & Weyers, 1996; Cline & Kainulainen, 1996; Laine & Rummukainen, 1998; Cohen, Morrissey, & Pierce,; Carena, Nardini, Quiros, & Wagner, 2012;
NMSSM / nMSSM / μνSSM	Pietroni, 1993; Davies, Froggatt, & Moorhouse, 1995; Huber & Schmidt, 2001; Ham, Oh, Kim, Yoo, & Son, 2004; Menon, Morrissey, & Wagner, 2004; Funakubo, Tao, & Toyoda, 2005; Huber, Kontandin, Prokopec, & Schmidt, 2006; Chung, AL, 2010, Huang, Kang, Shu, Wu, Yang, 2014; Bian, Guo, Shu (2017)
EFT-like Approach (H^6 operator)	Grojean, Servant, Wells, 2005; Huang, Gu, Yin, Yu, Zhang 2015; Huang, Joglekar, Li, Wagner, 2015; Huang, Wan, Wang, Cai, Zhang 2016; Huang, Gu, Yin, Yu, Zhang 2016; Cao, F.P. Huang, Xie, Zhang (2017)

(not to scale)

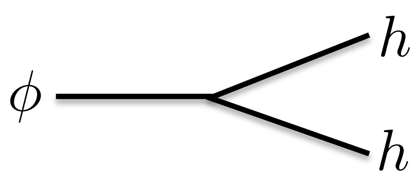
An example of new physics

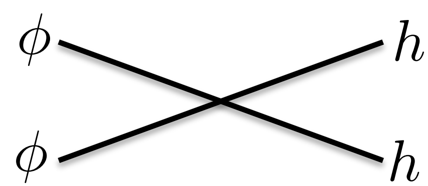
[Espinosa & Quiros (1993); Choi & Volkas (1993); McDonald (1994); Profumo, Ramsey-Musolf, & Shaughnessy (2007)]
[Chung, AL, & Wang (2012)]

Consider the theory

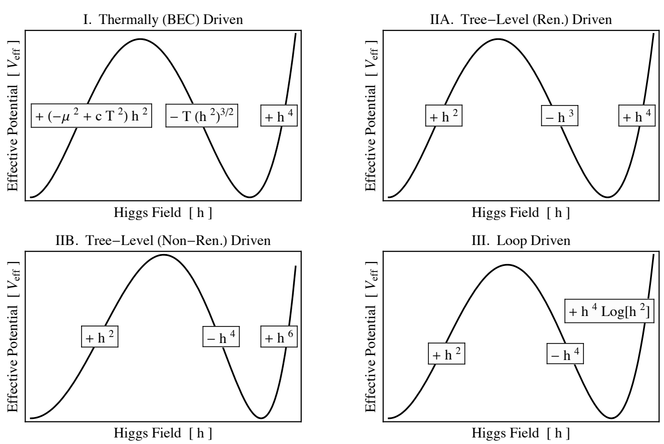
SM + a spin-0 colorless uncharged particle [i.e., real scalar singlet]

$$\mathscr{L} = \mathscr{L}_{\rm SM} + \frac{1}{2}(\partial\phi)^2 - a_2\,\phi^2 - a_3\,\phi^3 - a_4\,\phi^4 - \underline{b_1\,\phi H^\dagger H - b_2\,\phi^2 H^\dagger H}$$





Its interactions with the Higgs can lead to a 1st order EW PT



However such an inert particle is especially challenging to detect!

Indirect signatures: Higgs precision

[Craig, Englert, & McCullough (2013); McCullough (2014); Curtin, Meade, & Yu (2014)]

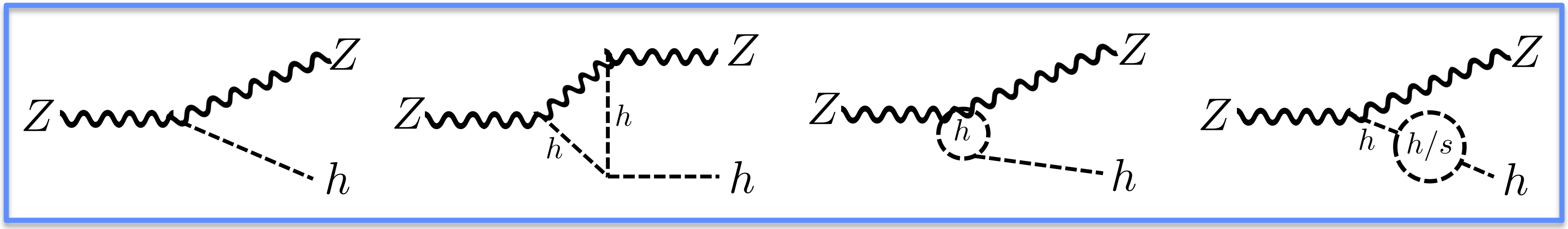
The new physics affects how strongly the Higgs couples to other SM particles such as the Z-boson

$$\frac{g_{hZZ}}{g_{hZZ,\mathrm{SM}}} \approx \cos\theta + 0.006\left(\frac{\lambda_3}{\lambda_{3,\mathrm{SM}}} - 1\right) - 2\frac{|a_{hs} + \lambda_{hs} v_s|^2}{16\pi^2} I_B(M_h^2; M_h^2, M_s^2) - \frac{|\lambda_{hs}|^2 v^2}{16\pi^2} I_B(M_h^2; M_s^2, M_s^2)\,.$$

(leading effect is from mixing)

(triangle probes self-coupling)

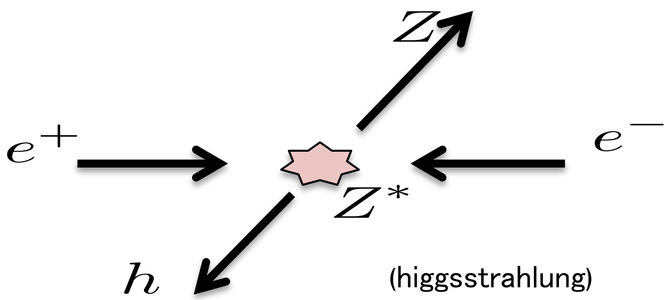
(Higgs wfcn. renorm.)



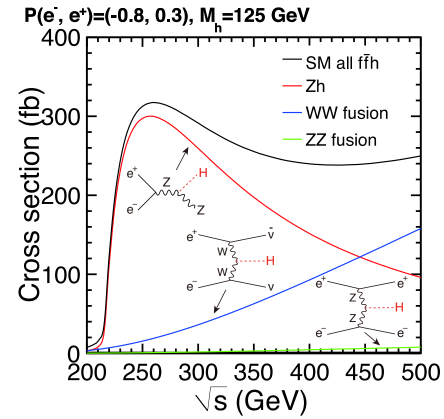
Current LHC measurements @ 27% precision [1606.02266]
Projected HL-LHC sensitivity is ~7% precision [1307.7135]

The future collider program

Higgs factory: e^+e^- @ E_{com} = 250 GeV



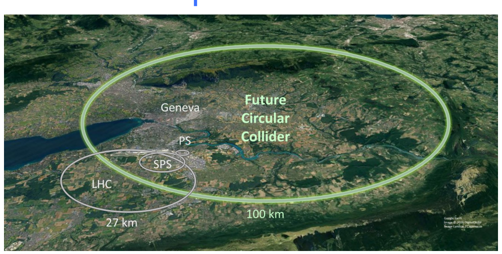
(higgsstrahlung)



a primary goal is to measure the hZZ coupling with sub-% precision

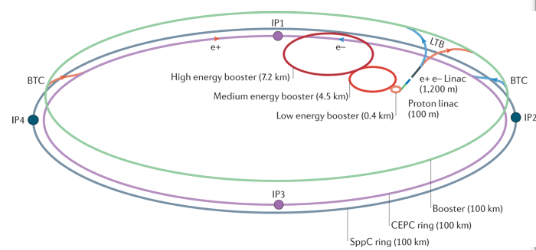
Future Circular Collider (FCC)

Europe / CERN



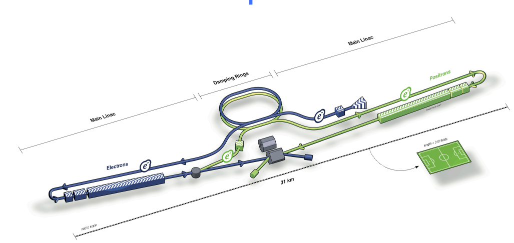
Circular Electron-Positron Collider (CEPC)

China



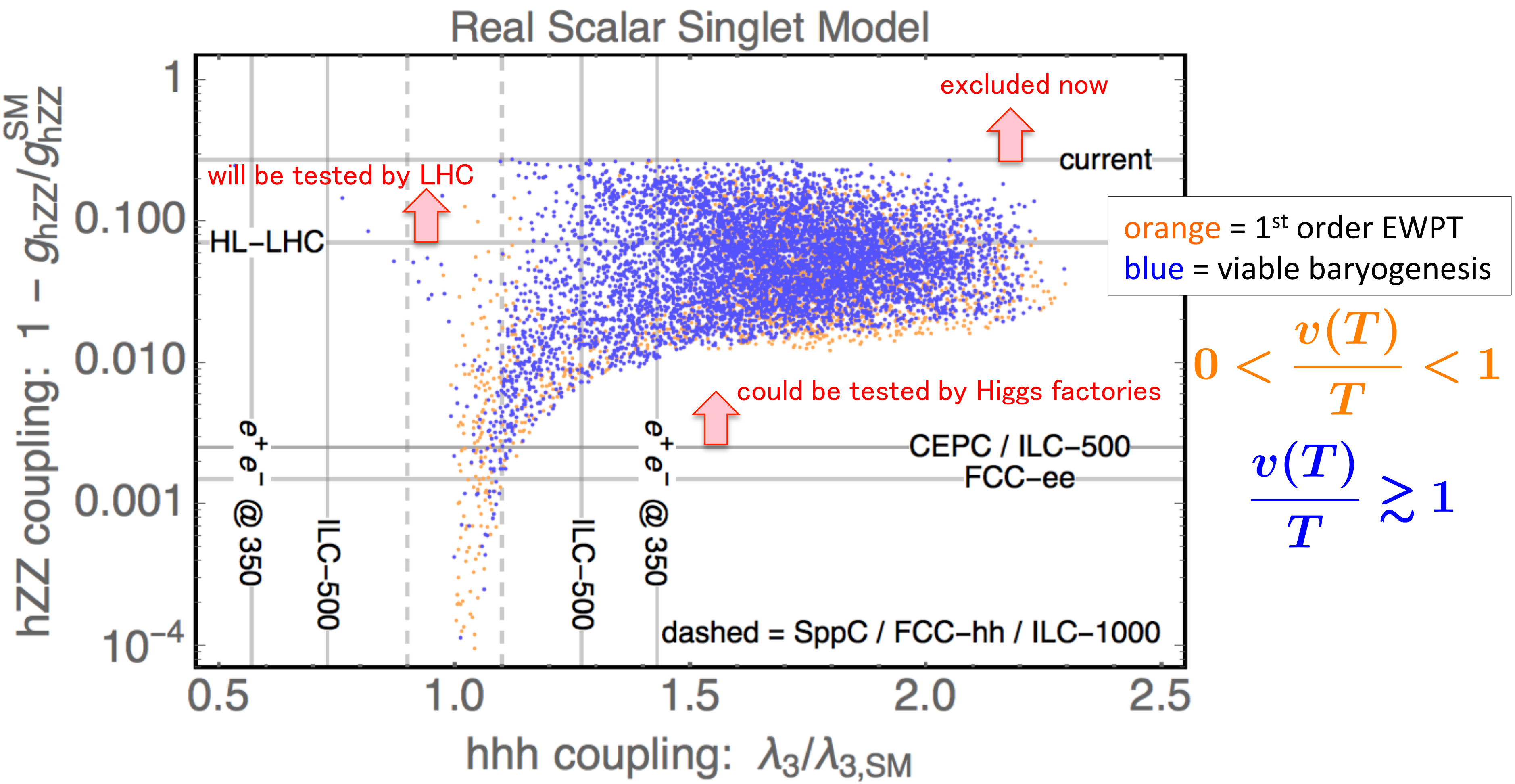
International Linear Collider (ILC)

Japan



Prospects for testing EW phase transition

[Huang, AL, & Wang (2016)]



$$0 < \frac{v(T)}{T} < 1$$

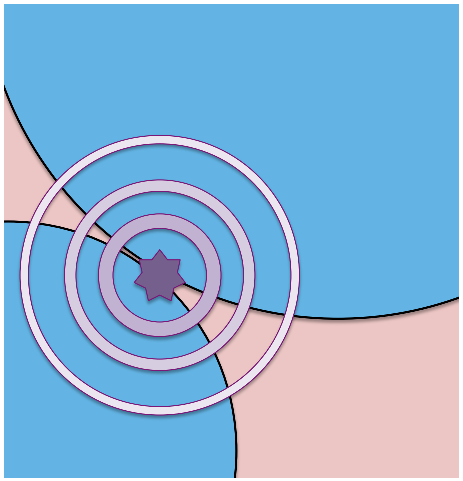
$$\frac{v(T)}{T} \gtrsim 1$$

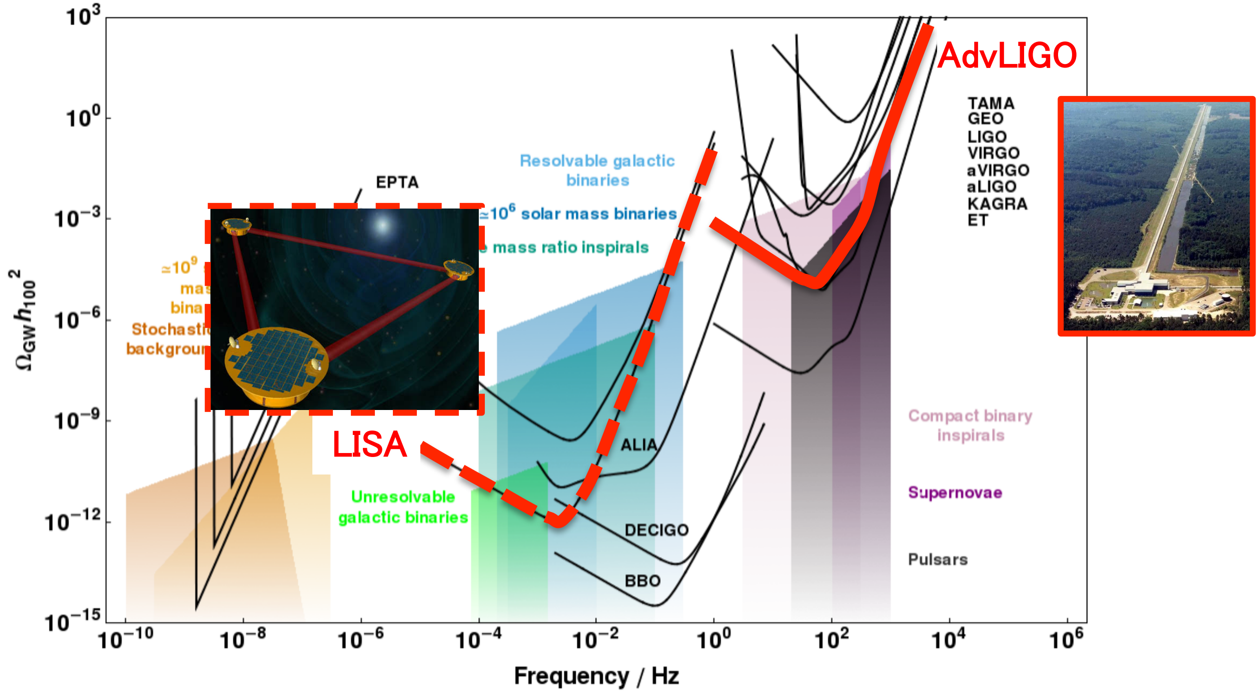
Complementarity with gravitational waves

[Caprini et. al. (2015)]

Bubble collisions & fluid motion create a gravitational wave noise

GW spectrum is set by the bubble size at the time of collision & typically falls right into the sensitivity band of future space-based GW interferometer telescopes

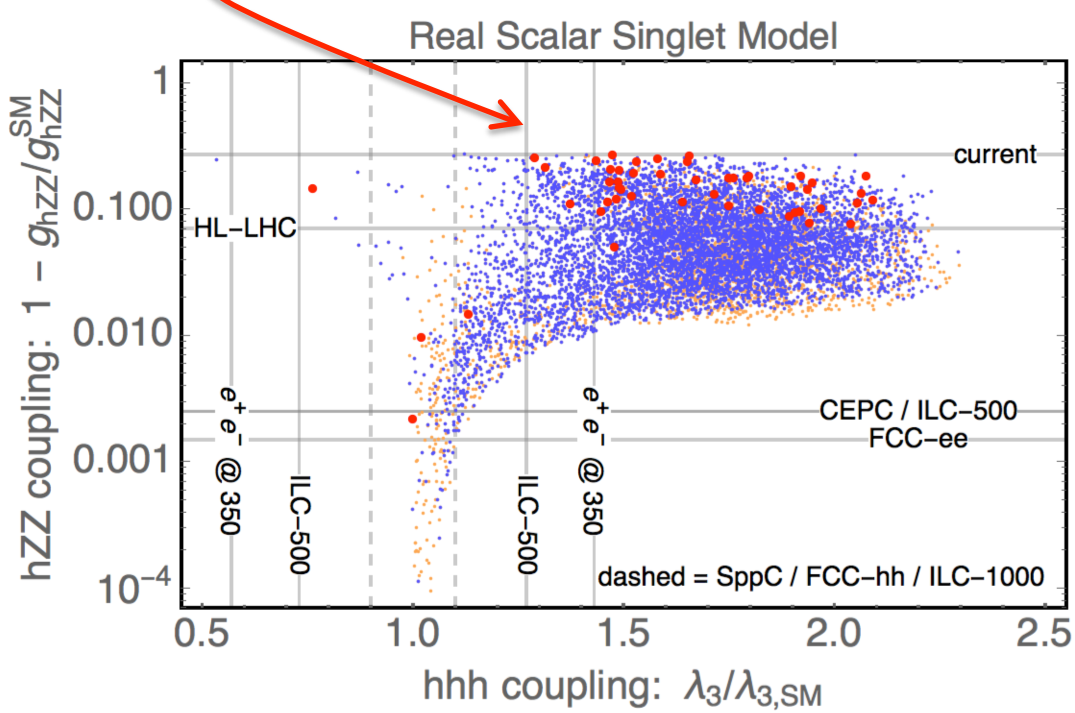




Complementarity with gravitational waves

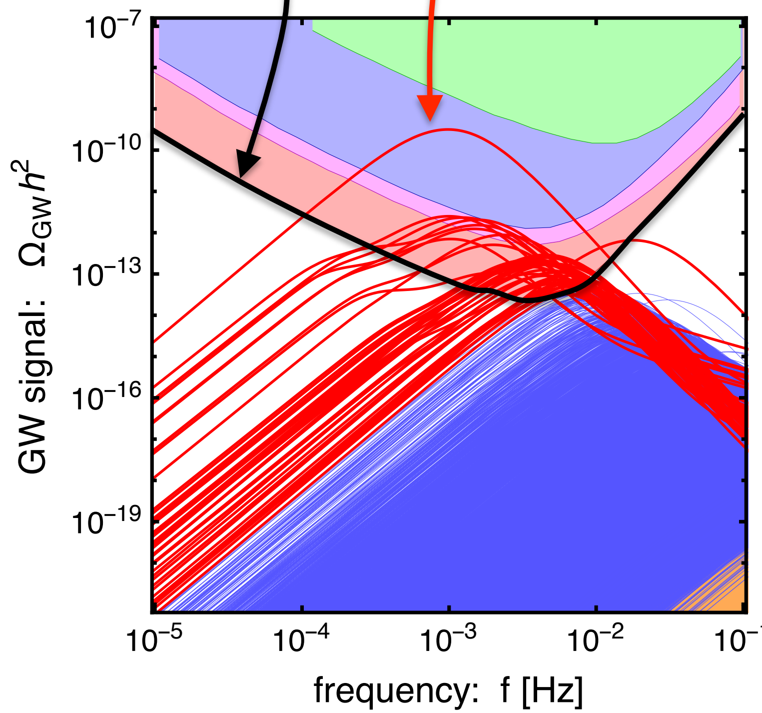
[Huang, AL, & Wang (2016)]

orange = 1st order EWPT
blue = also viable baryogenesis
red = also detectable GWs



LISA projected sensitivity

predicted grav. wave spectra



outline

(1) testing electroweak baryogenesis on the collider & cosmological frontiers

- The new physics required for EWBG has thus far evaded our grasp at the LHC.
- With precisions measurements of Higgs couplings (hZZ) at the HL-LHC upgrade and a future Higgs factory, we can test many of even the most elusive models.
- A deviation from SM predictions would give *indirect* evidence for the kind of new physics that leads to a first order EW phase transition, but a detection of the associated gravitational wave signal is the best *direct* evidence for a cosmological first order phase transition.

outline

(1) testing electroweak baryogenesis
on the collider & cosmological frontiers

(2) a new perspective on
baryogenesis from (lepto-)bubbles

(3) baryon asymmetry
from magnetic helicity

Alternate applications of our EWBG tool kit

While studying EW baryogenesis we've developed a big tool kit

We've learned how to calculate …

- … when the phase transition will be 1st order
- … phase transition temperature & order parameter
- … phase transition duration & latent heat
- … stochastic gravitational wave spectrum
- … CP-violating scattering at the bubble wall (source term)
- … charge diffusion in front of the wall
- … charge transport & washout

Can we use our tool kit to study BG at other phase transitions?

Symmetry breaking associated with

- … grand unification
- … lepton-number
- … flavor
- … dark sector
- … chiral symmetry
- … composite Higgs

see works by: Iason Baldes, Jim Cline, Eleanor Hall, Kimmo Kainulainen, Thomas Konstandin, Robert McGehee, Hitoshi Murayama, Kai Schmitz, Geraldine Servant, David Tucker-Smith, …

High-scale lepton-number violation

Tiny neutrino mass scale from huge L-violation mass scale

type-I seesaw: $$m_\nu \sim (0.1\ \text{eV}) \left(\frac{m_{\text{L-violation}}}{10^{12}\ \text{GeV}}\right)^{-1} \left(\frac{\lambda_N}{0.1}\right)^2$$

Consider the theory [singlet Majoron model]

SM + complex scalar ϕ + Weyl fermion N

$$\mathscr{L} = \mathscr{L}_{\text{SM}} - \frac{1}{2}\underline{\kappa\phi N N} - \lambda_N L H N + \text{h.c.}$$

Lepton-number is broken spontaneously by <ϕ>: $m_N = \kappa\, v_\phi / 2$.

If the corresponding phase transition is 1st order, we can do leptogenesis in the style of electroweak baryogenesis!

[Cohen, Kaplan, & Nelson (1990)]

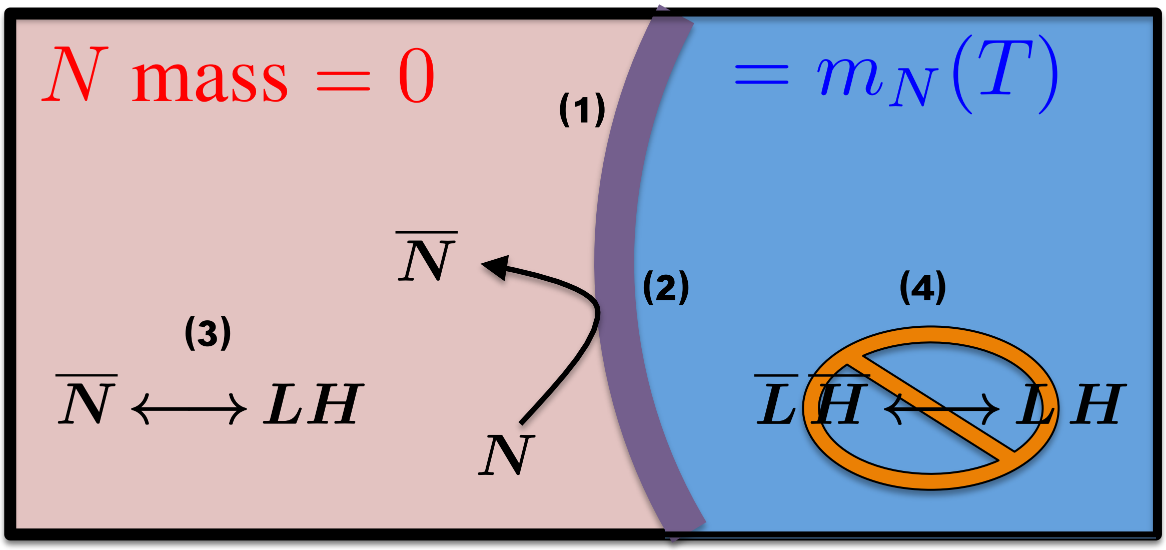
seesaw: [Minkowski (1977); Schechter & Valle (1980); Mohapatra, Rabindra, & Senjanovic (1980); Yanagida (1980); Mohapatra & Senjanovic (1981)]
singlet Majoron: [Chikashige, Mohapatra, & Peccei (1981); Gelmini & Roncadelli (1981)]

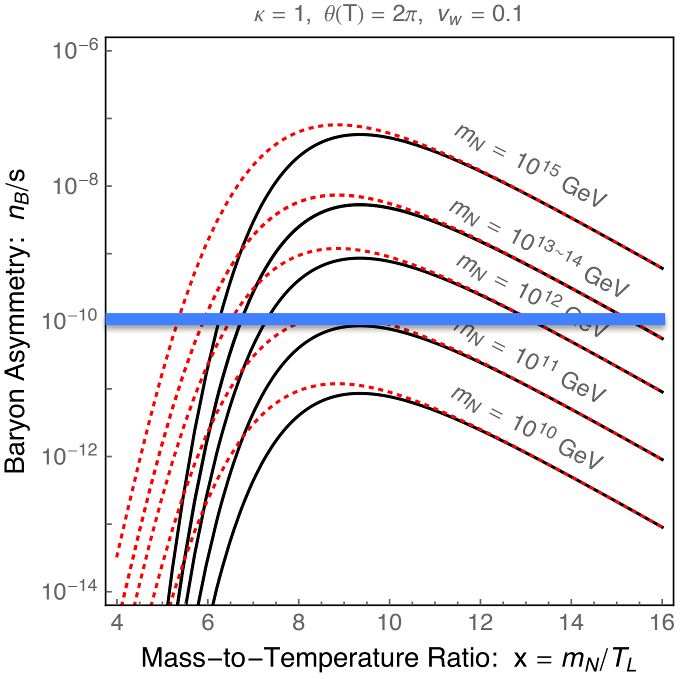
Leptogenesis from a L-number breaking phase transition

[AL, Tesi, Wang (2016)]
see also: [Pascoli, Turner, & Zhou (2016)]

The phase transition induces a mass for N

CP-violating scattering of N's at the bubble wall leads to an L-asymmetry



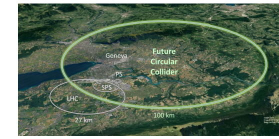


(1) First order phase transition
(2) CP-violating source
(3) Charge transport & diffusion
(4) Washout avoidance
(5) Electroweak sphaleron converts L→B

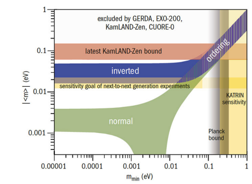
Washout avoidance requires $m_N >> T$
→ large couplings
→ or strong supercooling

Observational prospects are challenging

Particle physics



➔ Predicts: no collider signature of m ~ 10^{12} GeV particles!



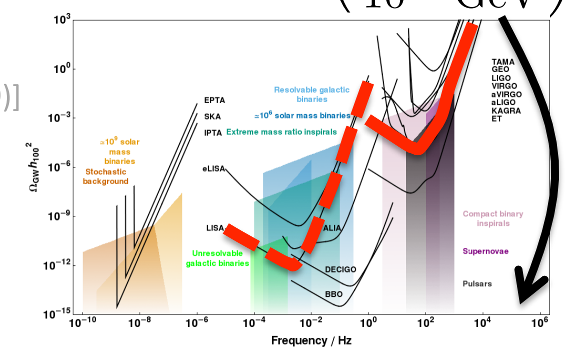
➔ Predicts: light neutrinos are Majorana & 0νββ may occur.
(but this is not really probing the physics of baryogenesis)

➔ Predicts: light pseudo-NGB *majoron* … constrained by astrophysics

Cosmological relics

➔ Predicts: stochastic gravitational waves background

$$f \gtrsim (10^5\ \mathrm{Hz}) \left(\frac{T_{PT}}{10^{11}\ \mathrm{GeV}} \right)$$



➔ Predicts: cosmic string network & GW signal

see also: [Dror, Hiramatsu, Kohri, Murayama, & White (2019)]

➔ Majorons might survive in the Universe today
as candidates for dark matter or dark radiation.

Lowering the scale of L-number violation

[work in progress w/ Raymond Co]

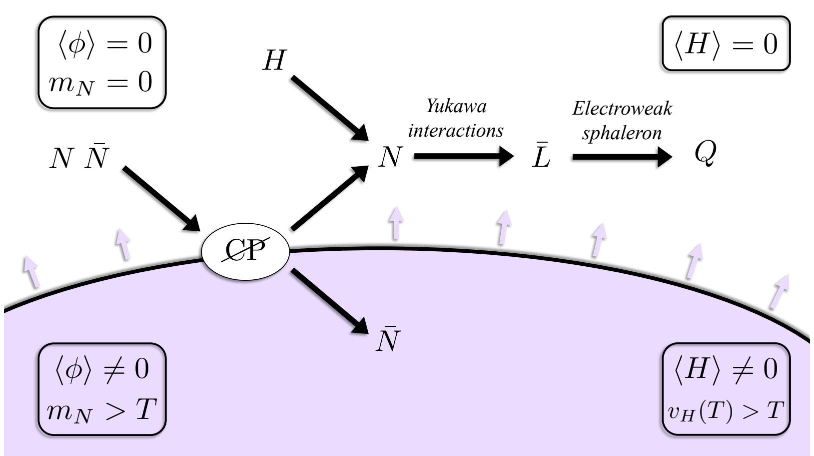
The tiny m_ν might instead result from low-scale L-number violation

inverse seesaw: $$m_\nu \sim (0.1\ \text{eV}) \left(\frac{\mu_{\text{L-violation}}}{0.01\ \text{keV}}\right) \left(\frac{\kappa\phi}{100\ \text{GeV}}\right)^2 \left(\frac{M_{\text{pseudo-Dirac}}}{1\ \text{TeV}}\right)^{-2}$$

Consider the theory

SM + complex scalar ϕ + Weyl fermion N **+ Weyl fermion S**

$$\mathscr{L} = \mathscr{L}_{\text{SM}} - \underline{\kappa\phi S N} - \lambda_N LHN - \frac{1}{2}\mu SS + \text{h.c.}$$

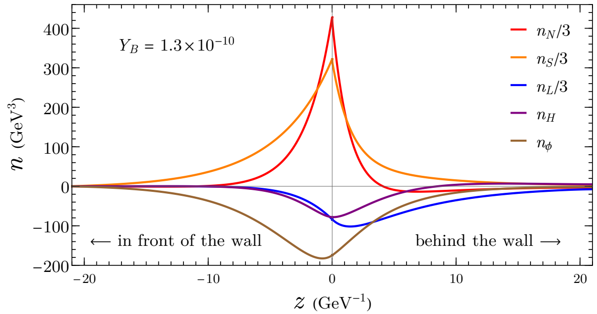


Lowering the scale of L-number violation

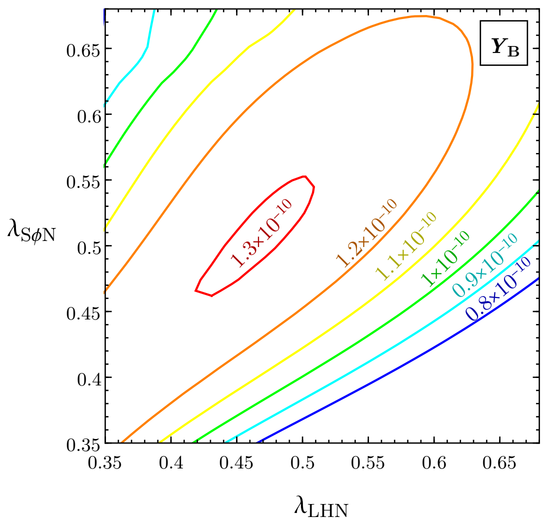
[work in progress w/ Raymond Co]

Baryogenesis

density profiles …

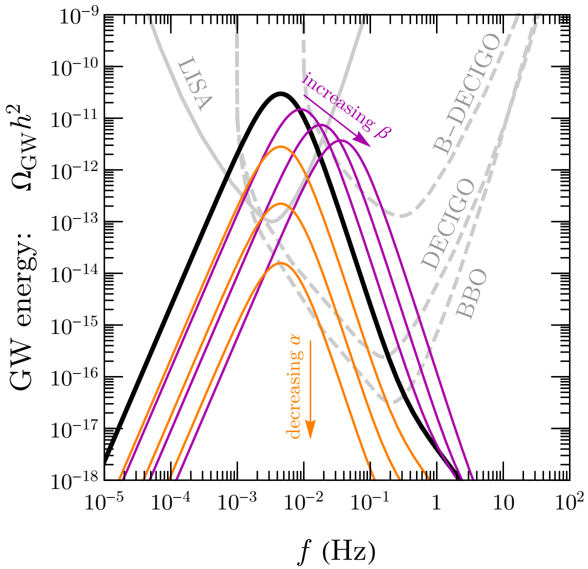


predicted baryon asymmetry …



Gravitational Waves

predicted GW spectrum …



outline

(1) testing electroweak baryogenesis on the collider & cosmological frontiers

(2) a new perspective on baryogenesis from (lepto-)bubbles

- The essence* of electroweak baryogenesis transcends the SM Higgs.
  (*CP-violating scattering & charge transport at bubble walls)
- An interesting direction to explore: EWBG-like dynamics at other symmetry-breaking phase transitions. E.g., lepton-number, flavor, dark sector, ...

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(3) baryon asymmetry from magnetic helicity

Let's go back to SM baryon-number violation

The chiral EW interactions lead to anomalies in B and L

$$\partial_\mu j^\mu_{\mathsf{B}} = \partial_\mu j^\mu_{\mathsf{L}} = 3 \times \left(\frac{g^2}{32\pi^2} W^a_{\mu\nu} \widetilde{W}^{a\mu\nu} - \frac{g'^2}{32\pi^2} Y_{\mu\nu} \tilde{Y}^{\mu\nu} \right)$$

(EW instanton & sphaleron)

Can we use the $\mathrm{U(1)_Y}$ term to do baryogenesis also?

It vanishes in vacuum but becomes nonzero when a $\mathrm{B_Y}$ field is present.

Changing U(1)$_Y$ helicity sources B-number

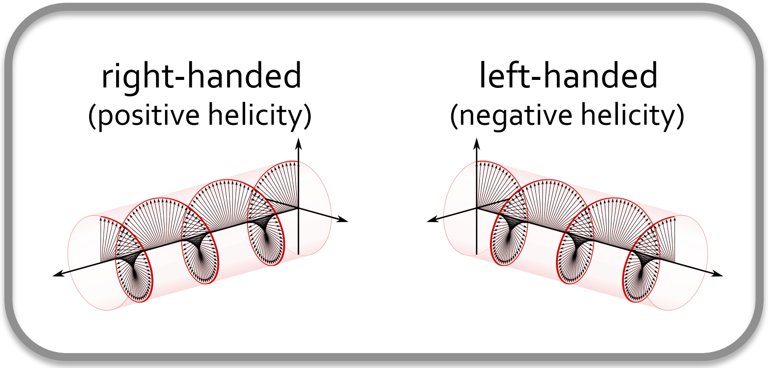
[Joyce & Shaposhnikov (1997); Giovannini & Shaposhnikov (1997); Fujita & Kamada (2016)]

A helical hypermagnetic field provides support for the U(1)Y term

$$\langle Y_{\mu\nu}\tilde{Y}^{\mu\nu}\rangle = -4\boldsymbol{E}_Y \cdot \boldsymbol{B}_Y = 2\Big[\partial_t\big(\boldsymbol{A}\cdot\boldsymbol{B}\big) + \boldsymbol{\nabla}\cdot\big(\phi\boldsymbol{B} + \boldsymbol{E}\times\boldsymbol{A}\big)\Big]$$

Changing helicity induces B-number

$$\Delta Q_{\mathrm{B}} = -3\frac{g'^2}{16\pi^2}\Delta\mathcal{H}_Y$$



The helicity decays in a plasma because of ohmic losses (finite σ_Y)

$$\boldsymbol{E}_Y = \boldsymbol{j}_Y/\sigma_Y \approx \boldsymbol{\nabla}\times\boldsymbol{B}_Y/\sigma_Y$$

$$\langle Y_{\mu\nu}\tilde{Y}^{\mu\nu}\rangle = -4\langle\boldsymbol{B}_Y\cdot\boldsymbol{\nabla}\times\boldsymbol{B}_Y\rangle/\sigma_Y$$

Decaying magnetic helicity provides an avenue for baryogenesis!

Baryogenesis from decaying magnetic helicity

[Kamada & AL (2016a,b)]

Recipe for baryogenesis

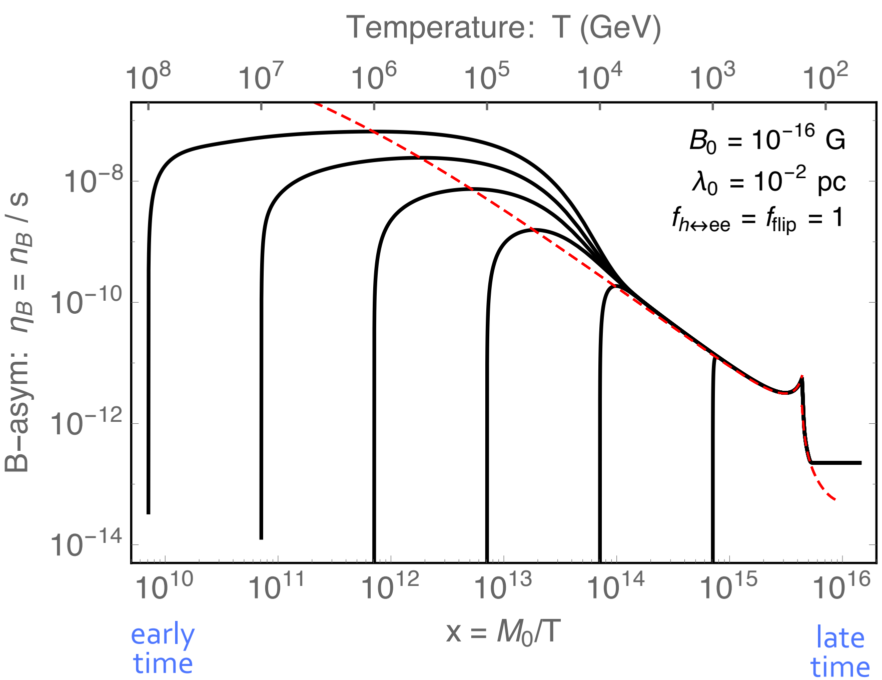
(1) Make a helical magnetic field (e.g., axion inflation)
(2) Universe reheats above the EW scale
(3) B-field evolution given by MHD (inverse cascade)
(4) Decaying helicity sources B-number (EW anomaly)
(5) Solve transport equations to calculate baryon asymmetry

basic idea:

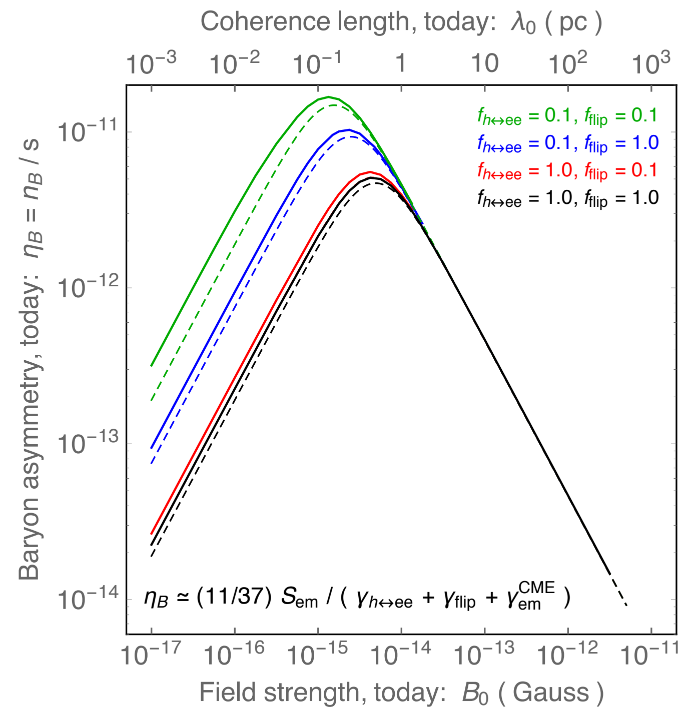
$$\dot{n}_{\rm B} = -\Gamma_{\rm sphaleron}\, n_{\rm B} + S_{\rm helicity}$$

$$\Rightarrow\quad n_{\rm B} \sim S_{\rm helicity} \,/\, \Gamma_{\rm sphaleron}$$

time evolution



relic baryon asymmetry



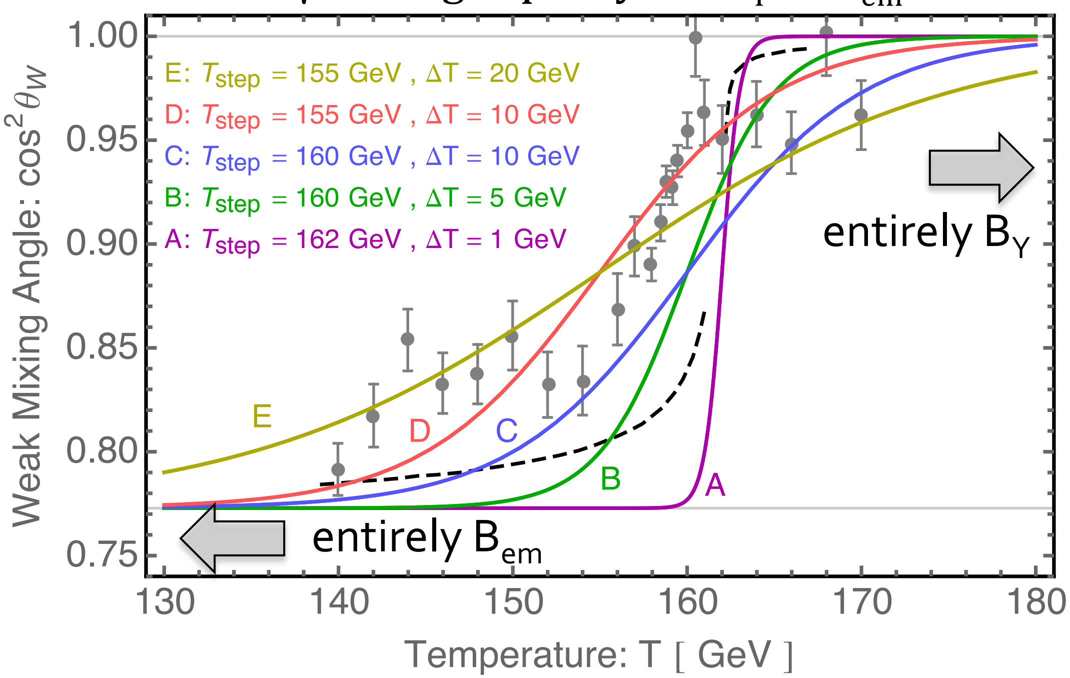
for additional details, see Kohei Kamada's talk on Tuesday afternoon
see also: Jimenez, Kamada, Schmitz, & Xu (2017)

Modeling the field evolution during EW phase transition

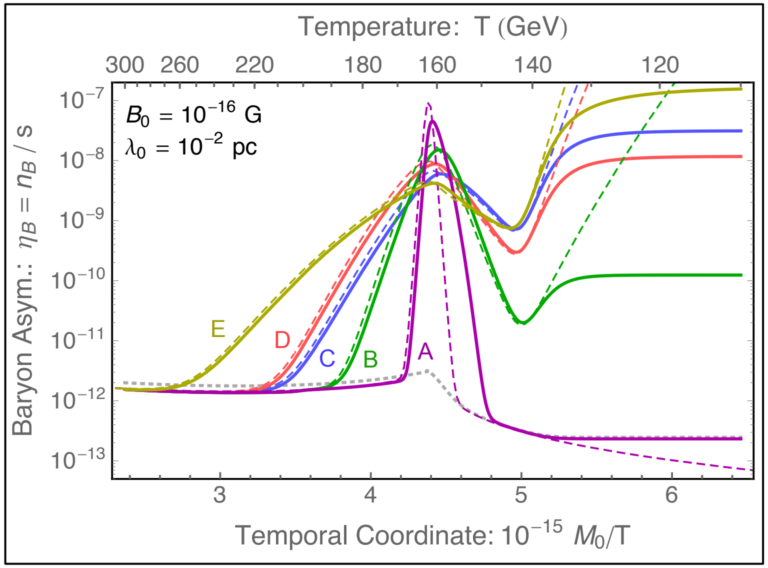
[Kamada & AL (2016a,b)]

Predicted asymmetry depends on how you model $U(1)_Y \rightarrow U(1)_{EM}$

Z-γ mixing is proxy for B_Y to B_{em}



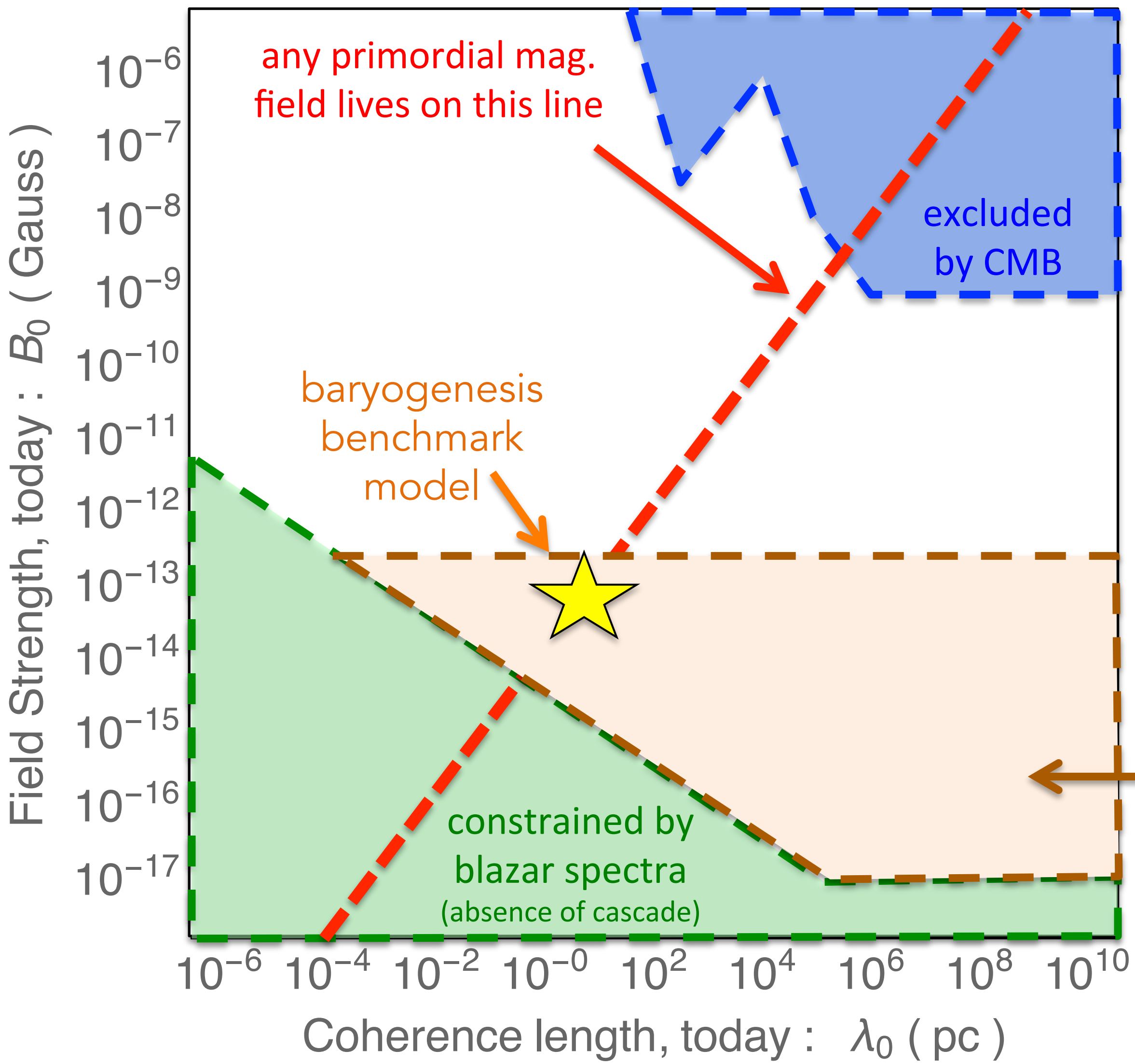
time evolution



for additional details, see Kohei Kamada's talk on Tuesday afternoon

Testing BG-from-PMF

adapted from: [Durrer & Neronov (2013)]



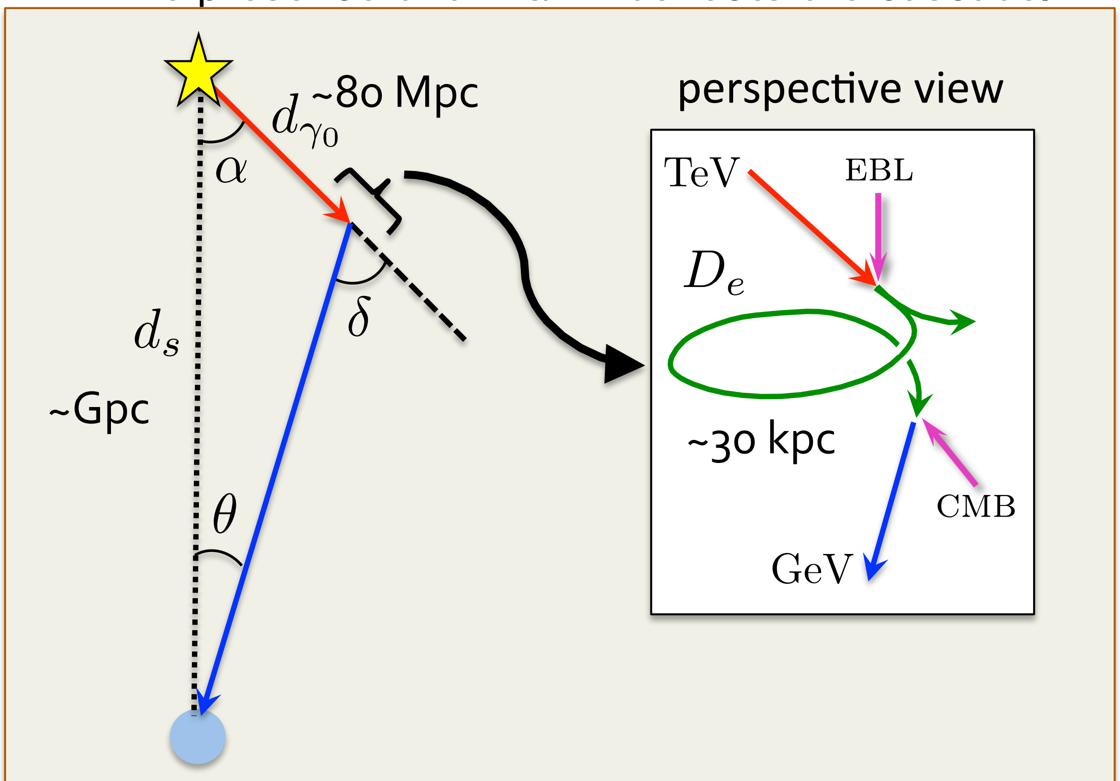
The relic of the primordial magnetic field is an intergalactic magnetic field today.

Detecting IGMF with TeV blazars

[Aharonian, Coppi, & Voelk (1994); Neronov & Semikoz (2006); AL & Vachaspati (2016)]

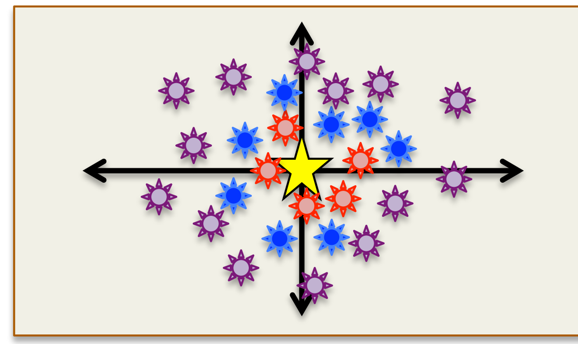
Gamma rays from TeV blazars develop an electromagnetic cascade by scattering on starlight (EBL) and cosmic microwave background (CMB) photons.

The presence of an IGMF deflects the cascade.

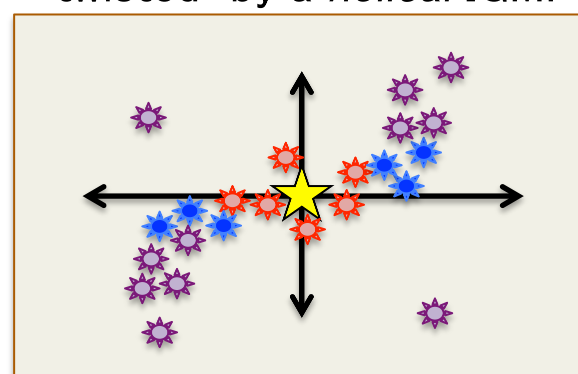


$$\Theta_{\rm ext} \simeq (0.68^\circ) \left(\frac{B_0}{10^{-15}\,{\rm G}}\right) \left(\frac{E_\gamma}{10\,{\rm GeV}}\right)^{-3/2} \left(\frac{d_s}{1\,{\rm Gpc}}\right)^{-1}$$

the blazar acquires a halo



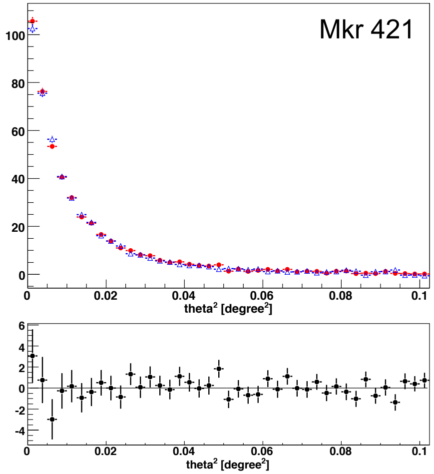
the blazar halo becomes "twisted" by a *helical* IGMF



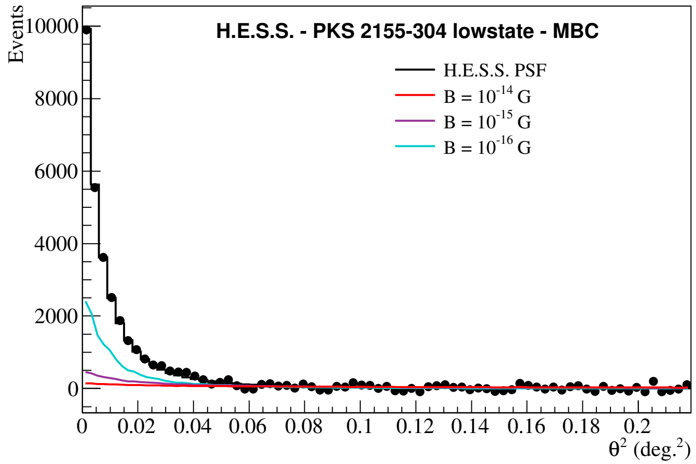
Prospects for finding an intergalactic magnetic field

Ongoing experimental efforts …

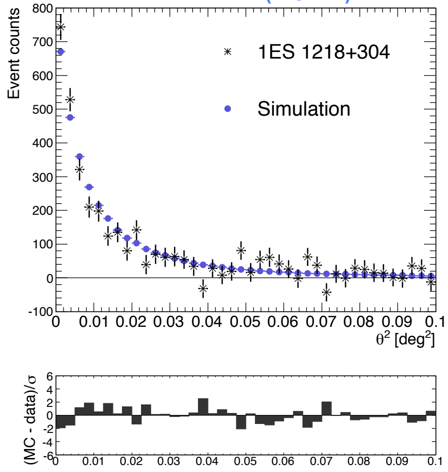
MAGIC (2010)



HESS + Fermi-LAT (2014)



VERITAS (2017)



A halo is not observed ➔ some of the IGMF parameter space is excluded:

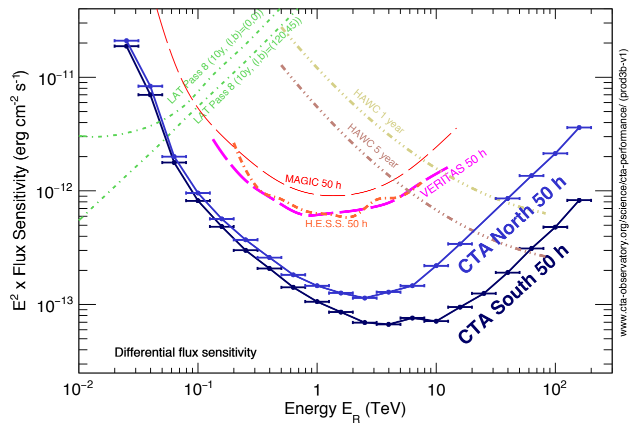
$$B_0 \sim (0.3 - 70) \times 10^{-15}\,\mathrm{G} \quad \mathrm{for} \quad \lambda_0 = 1\,\mathrm{Mpc}$$

Prospects for finding an intergalactic magnetic field

[Meyer, Conrad, & Dickinson (2016);   CTA Science Book (2017)]

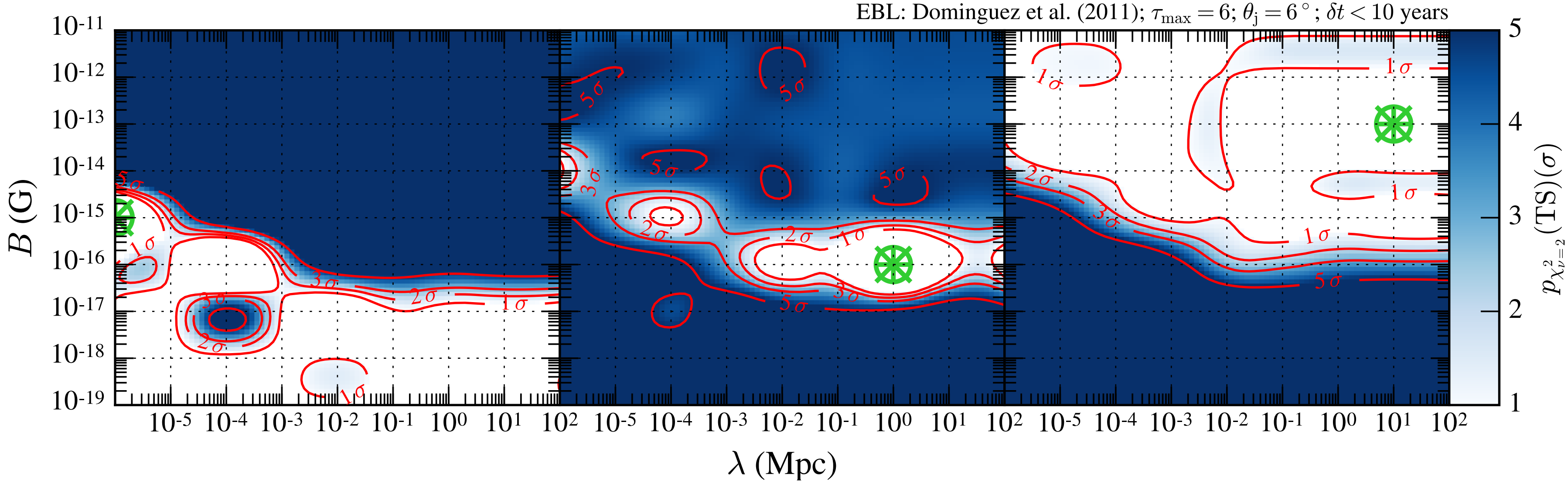
On the horizon…

The Cherenkov Telescope Array (CTA) will dramatically improve the flux sensitivity & angular resolution (PSF).



Implications for IGMF contraints:

Benchmark models (3, green). Corresponding exclusions (blue).



outline

(1) testing electroweak baryogenesis on the collider & cosmological frontiers

(2) a new perspective on baryogenesis from (lepto-)bubbles

(3) baryon asymmetry from magnetic helicity

- In addition to the EW instanton & sphaleron, the SM predicts B-number violation through changing hypermagnetic helicity as well.
- Lots of interesting directions: How did the helical $U1_Y$ field arise in the first place? How do these fields evolve through the EW crossover? What's the best way to detect their presence in the universe today?

My Perspective on Baryogenesis

If the EW phase transition is first order, as required by electroweak baryogenesis, then LHC upgrades & future colliders are well-suited to find the new physics.

The essence of EW baryogenesis lives on by clever application of the EWBG tool kit to other cosmological phase transitions.

The SM predicts B-number violation from changing helicity of hypermagnetic fields, which provides a new avenue for BG that can be tested with high-energy astro-particle observables.

New Perspectives on Baryogenesis

Neutrino Option Leptogenesis	*Jessica Turner*
Grey Room 2, IFT	16:40 - 17:00
Type-I Seesaw as the Common Origin of Neutrino Mass, Baryon Asymmetry, and the Electroweak Scale	*Kai Ruven Schmitz*
Preheating confronts leptogenesis	*Djuna Croon*
Grey Room 2, IFT	17:20 - 17:40
Baryogenesis from Primordial Helical Hypermagnetic Fields	*Kohei Kamada*
Red Room, IFT	17:10 - 17:30
The baryon asymmetry from a composite Higgs	*Oleksii Matsedonskyi*
Red Room, IFT	17:30 - 17:50
High Scale Electroweak Baryogenesis	*Dr Iason Baldes*
Red Room, IFT	17:50 - 18:10
Parameter space of baryogenesis in the νMSM	*Inar Timiryasov*
Grey Room 2, IFT	14:15 - 14:35
Low-scale leptogenesis with three heavy neutrinos	*Juraj Klaric*
Grey Room 2, IFT	14:35 - 14:55
Leptogenesis in the Scotogenic model	*Vedran Brdar*
Grey Room 2, IFT	14:55 - 15:15
Baryogenesis and Dark Matter from B Mesons	*Miguel Escudero*
Grey Room 2, IFT	15:40 - 16:00
All-in-one relaxion	*Jakub Scholtz*
Grey Room 2, IFT	16:00 - 16:20
Leptogenesis without Loops	*Arnab Dasgupta*
Grey Room 2, IFT	16:20 - 16:40