Fast Radio Bursts
and the
Origin of Cosmic Magnetic Fields

Stefan Hackstein

University of Hamburg

stefan.hackstein@hs.uni-hamburg.de

slides on: github.com/shackste/publications

Coll.: M. Brüggen, F. Vazza, B. Gaensler, S. Gottlöber, J. Sorce, L. Rodrigues
V. Heesen, T. Piro

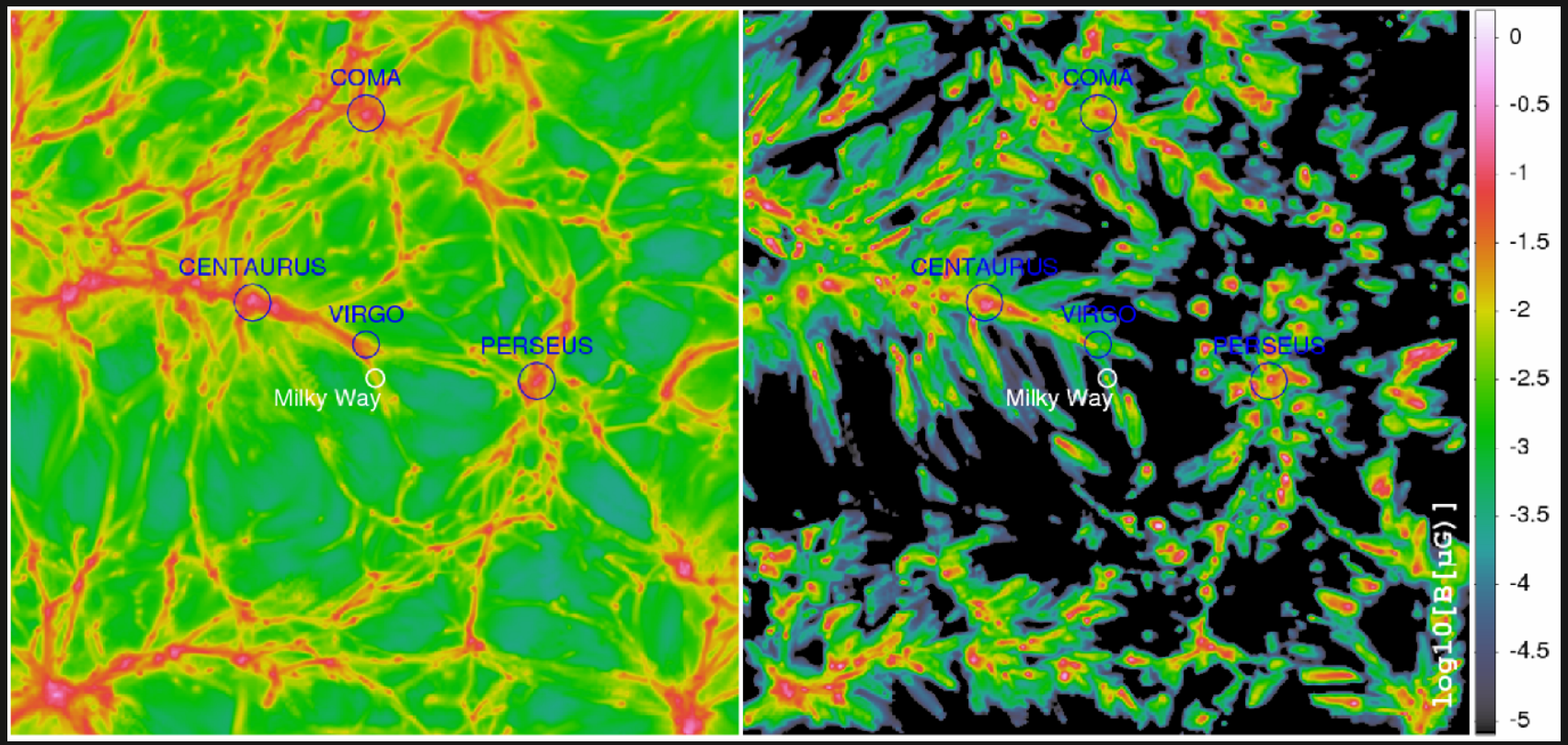
October 14th, 2020

What is the Origin of Cosmic Magnetic Fields?

Origin of Magnetic Fields

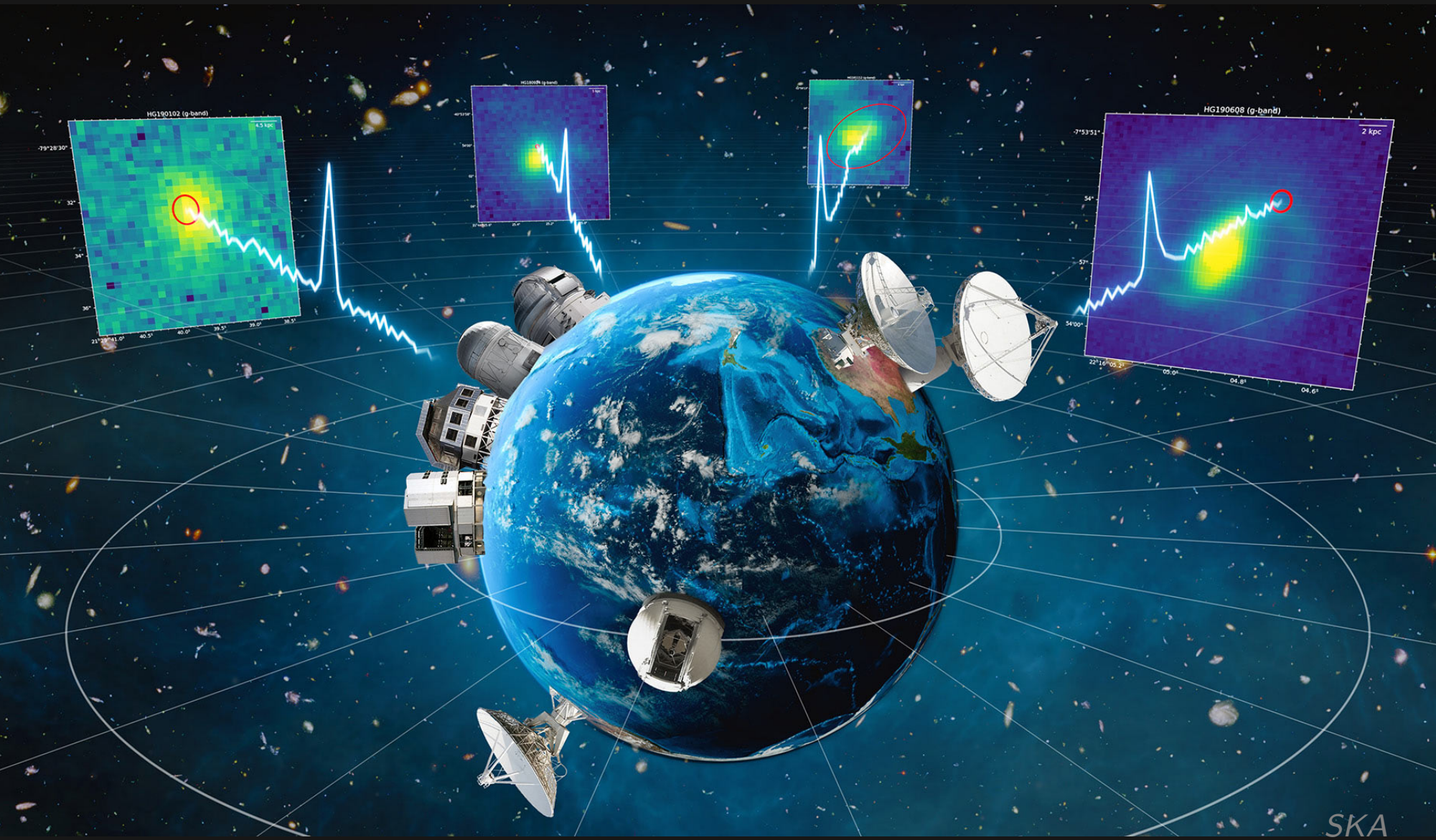
primordial

astrophysical

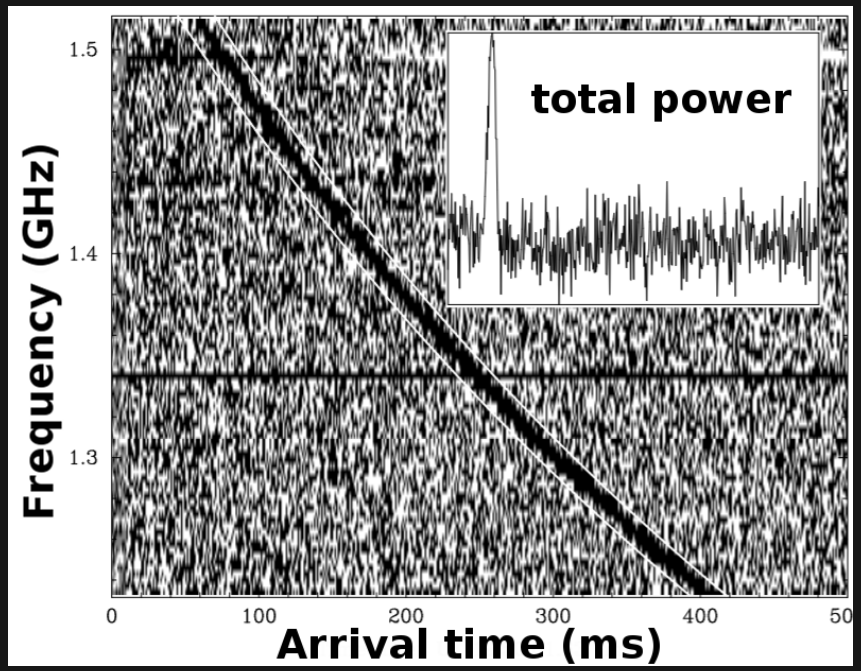


Hackstein+ 2018, F. Vazza

Fast Radio Bursts


HG190102 (g-band)
4.5 kpc
HG190608 (g-band)
2 kpc
SKA

First FRB

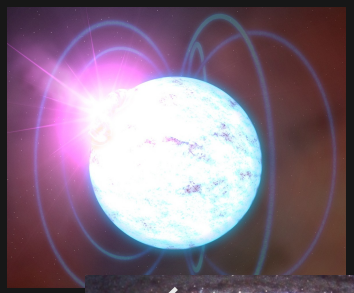


Lorimer+ 2007

$t(\nu) \propto \mathrm{DM}\ \nu^{-2}$
$\rightarrow$plasma dispersion

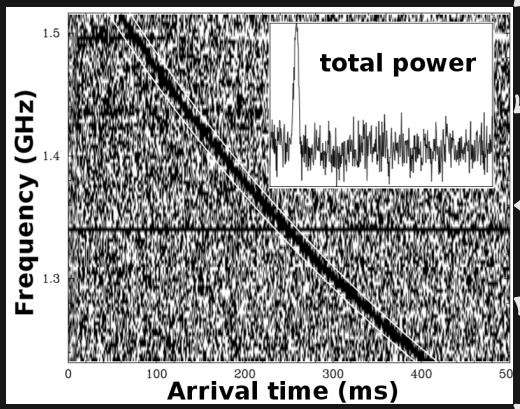
$\mathrm{DM} = \int n_e\ \mathrm{d}l > \mathrm{DM}_{\mathrm{MW}}$

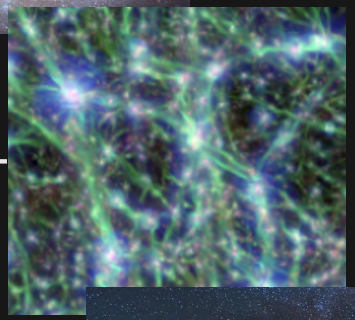
polarized
$\rightarrow \mathrm{RM} \propto \int B_{\parallel}\ n_e\ \mathrm{d}l$



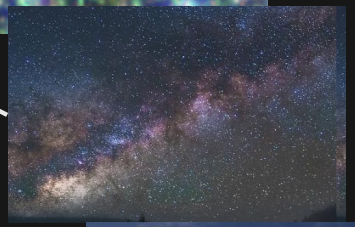
source

host





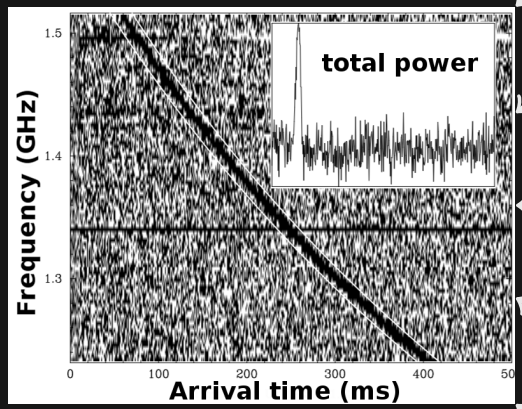
IGM

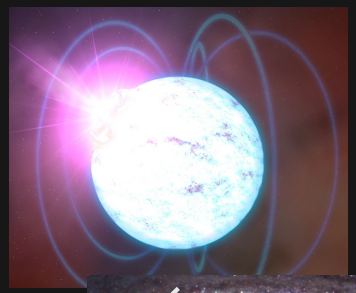


MW

tele

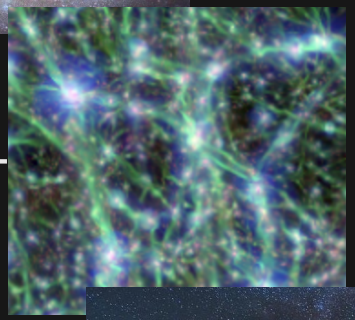
& intervening galaxies



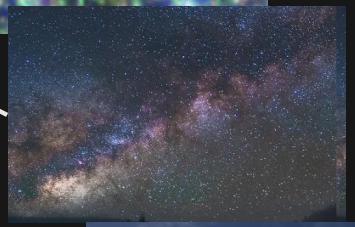


source
- magnetar
- merger

host
- stellar mass
- star formation rate



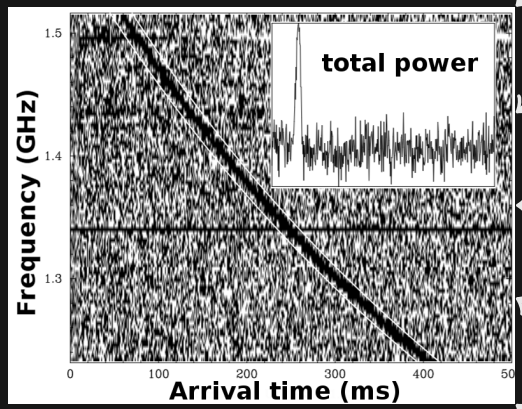
IGM
- primordial
- astrophysical

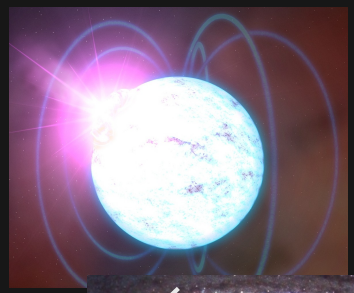


MW
- NE2001
- YMW16

tele
- CHIME
- ASKAP

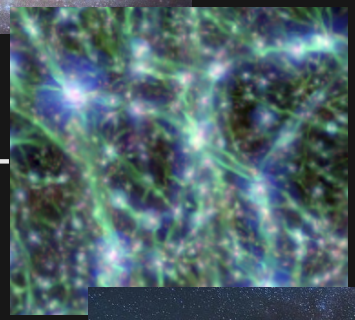
& intervening galaxies



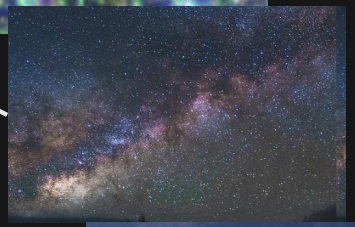


source → **magnetar**
merger

host → stellar mass
star formation rate



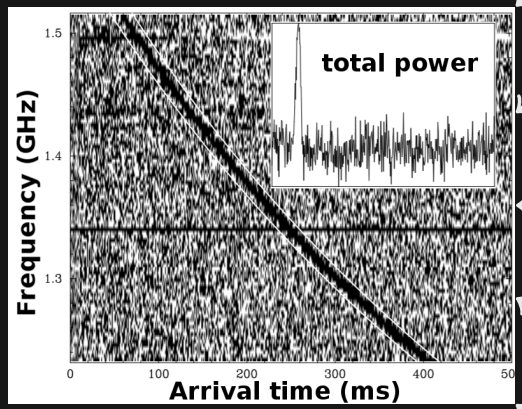
IGM → **primordial**
astrophysical

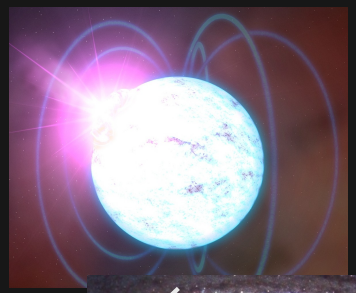


MW → NE2001
YMW16

tele → CHIME
ASKAP

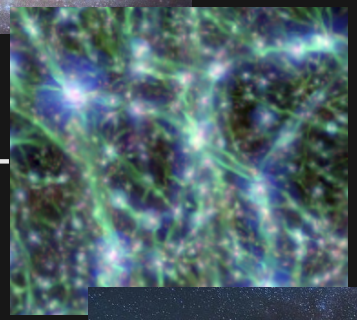
& intervening galaxies



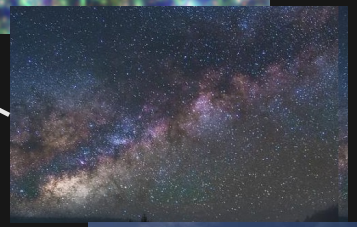


source
- **magnetar**
- merger

host
- stellar mass
- star formation rate



IGM
- primordial
- **astrophysical**



MW
- NE2001
- YMW16

tele
- CHIME
- ASKAP

& intervening galaxies

Benchmark scenario

Source magnetar *Piro&Gaensler 2018, Hackstein+ 2019*

Benchmark scenario

Source magnetar *Piro&Gaensler 2018, Hackstein+ 2019*

IGM constrained MHD simulation *F. Vazza, Hackstein+ 2018,'19*

Benchmark scenario

Source magnetar *Piro&Gaensler 2018, Hackstein+ 2019*

IGM constrained MHD simulation *F. Vazza, Hackstein+ 2018,'19*

Host galaxy ensemble $>$ 90% *of galaxies & evolution*

Lacey+ 2016,Rodrigues+ 2018

Benchmark scenario

Source	magnetar	*Piro&Gaensler 2018, Hackstein+ 2019*
IGM	constrained MHD simulation	*F. Vazza, Hackstein+ 2018,'19*
Host	galaxy ensemble	$>$ 90% *of galaxies & evolution* *Lacey+ 2016,Rodrigues+ 2018*
Intervening	galaxy ensemble	*intersection probability*

Benchmark scenario

Source	magnetar	*Piro&Gaensler 2018, Hackstein+ 2019*
IGM	constrained MHD simulation	*F. Vazza, Hackstein+ 2018,'19*
Host	galaxy ensemble	$> 90\%$ *of galaxies & evolution*
		Lacey+ 2016,Rodrigues+ 2018
Intervening	galaxy ensemble	*intersection probability*
Redshift	distribution $\pi(z)$	FRBPOPPY, *Gardenier+ 2020*

Benchmark scenario

Source	magnetar	*Piro&Gaensler 2018, Hackstein+ 2019*
IGM	constrained MHD simulation	*F. Vazza, Hackstein+ 2018,'19*
Host	galaxy ensemble	$> 90\%$ *of galaxies & evolution*
		Lacey+ 2016,Rodrigues+ 2018
Intervening	galaxy ensemble	*intersection probability*
Redshift	distribution $\pi(z)$	FRBPOPPY, *Gardenier+ 2020*

$\rightarrow$ **most realistic estimate**
DM, RM
for
Parkes, ASKAP, CHIME, ...

PrEFRBLE

"Probability Estimates for FRBs $\rightarrow$ model Likelihood Estimates"

Hackstein 2020

$\rightarrow$ systematic model comparison

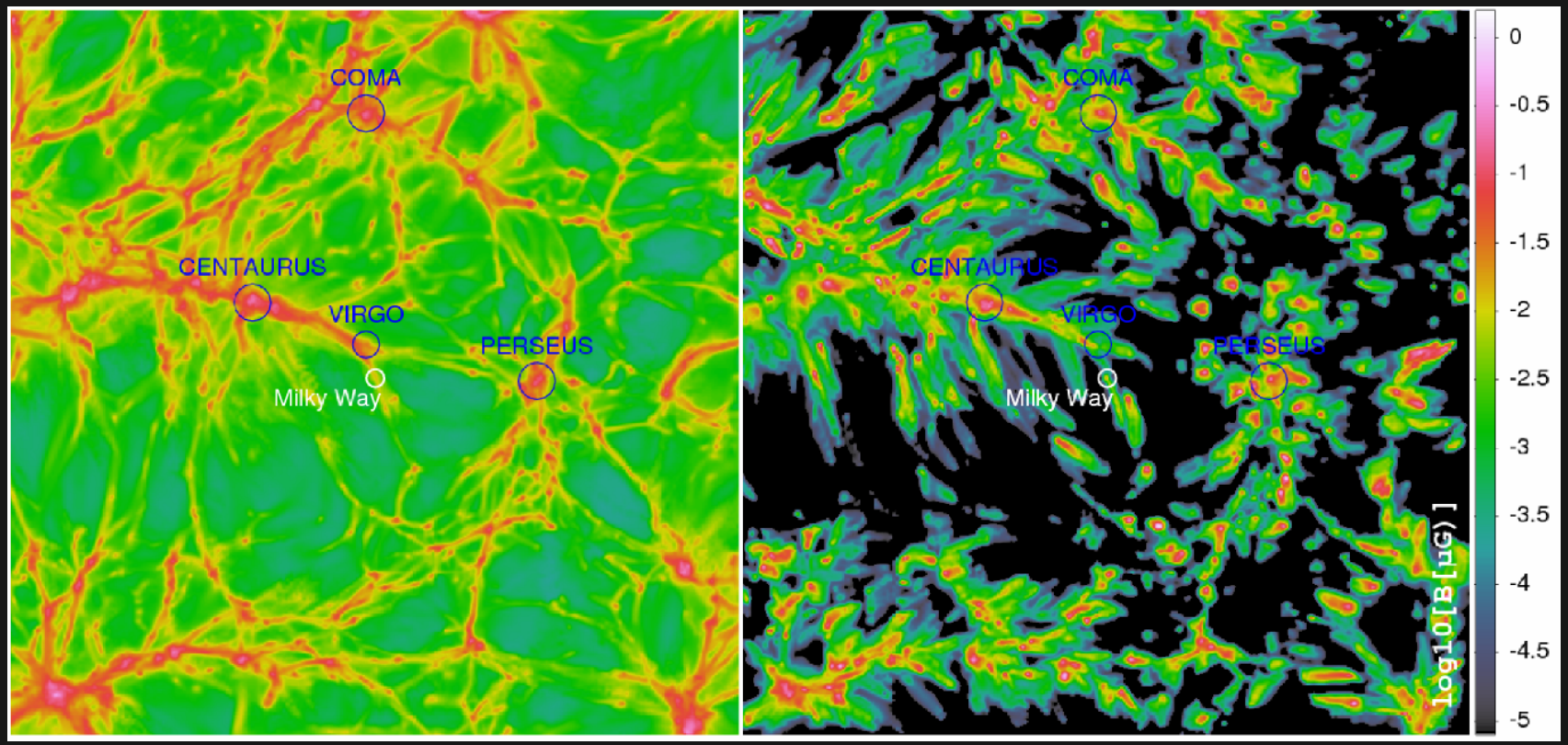
Approximate Bayesian Computation

open-source python package

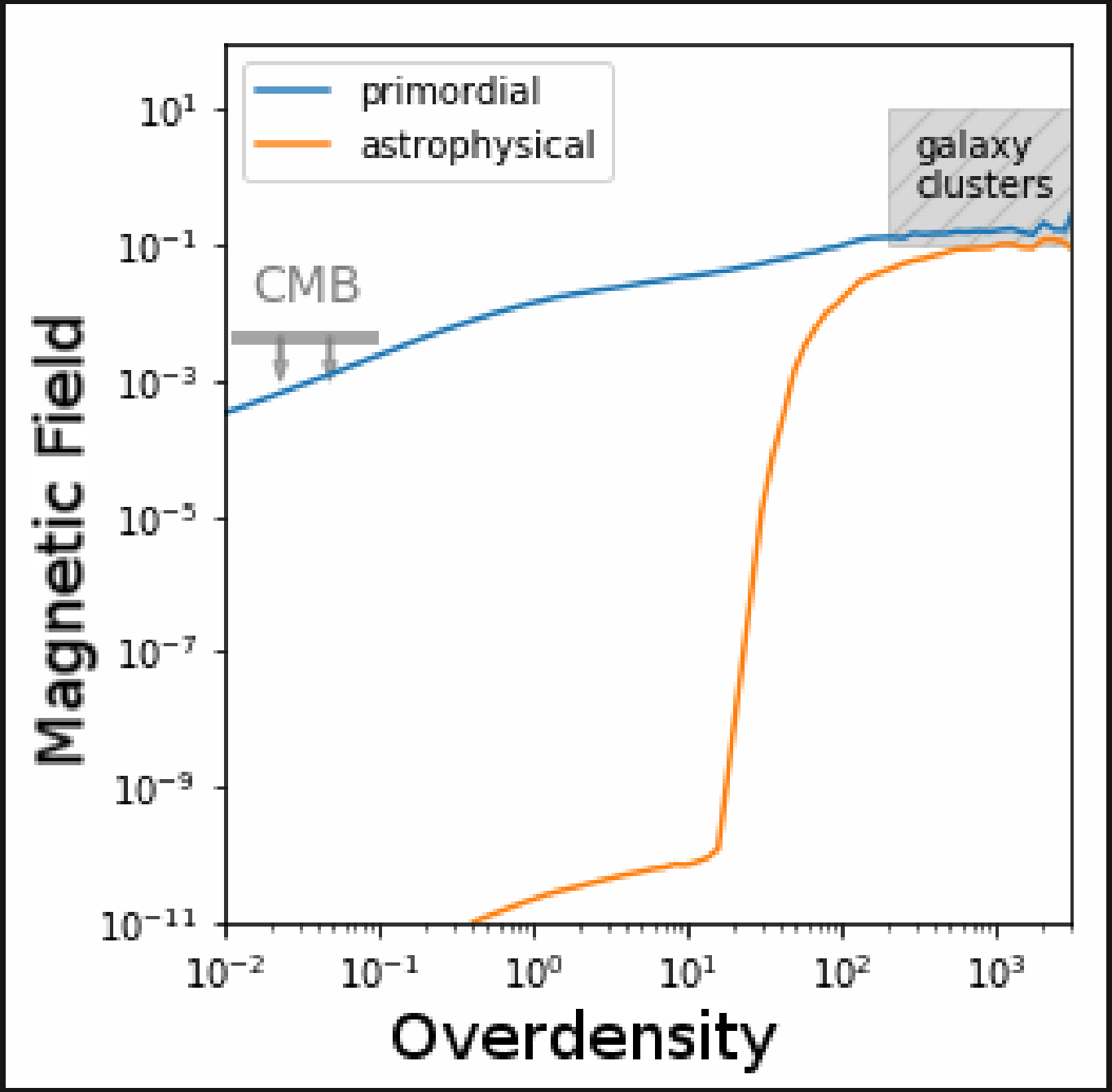
github.com/FRBs/PrEFRBLE

Origin of Magnetic Fields

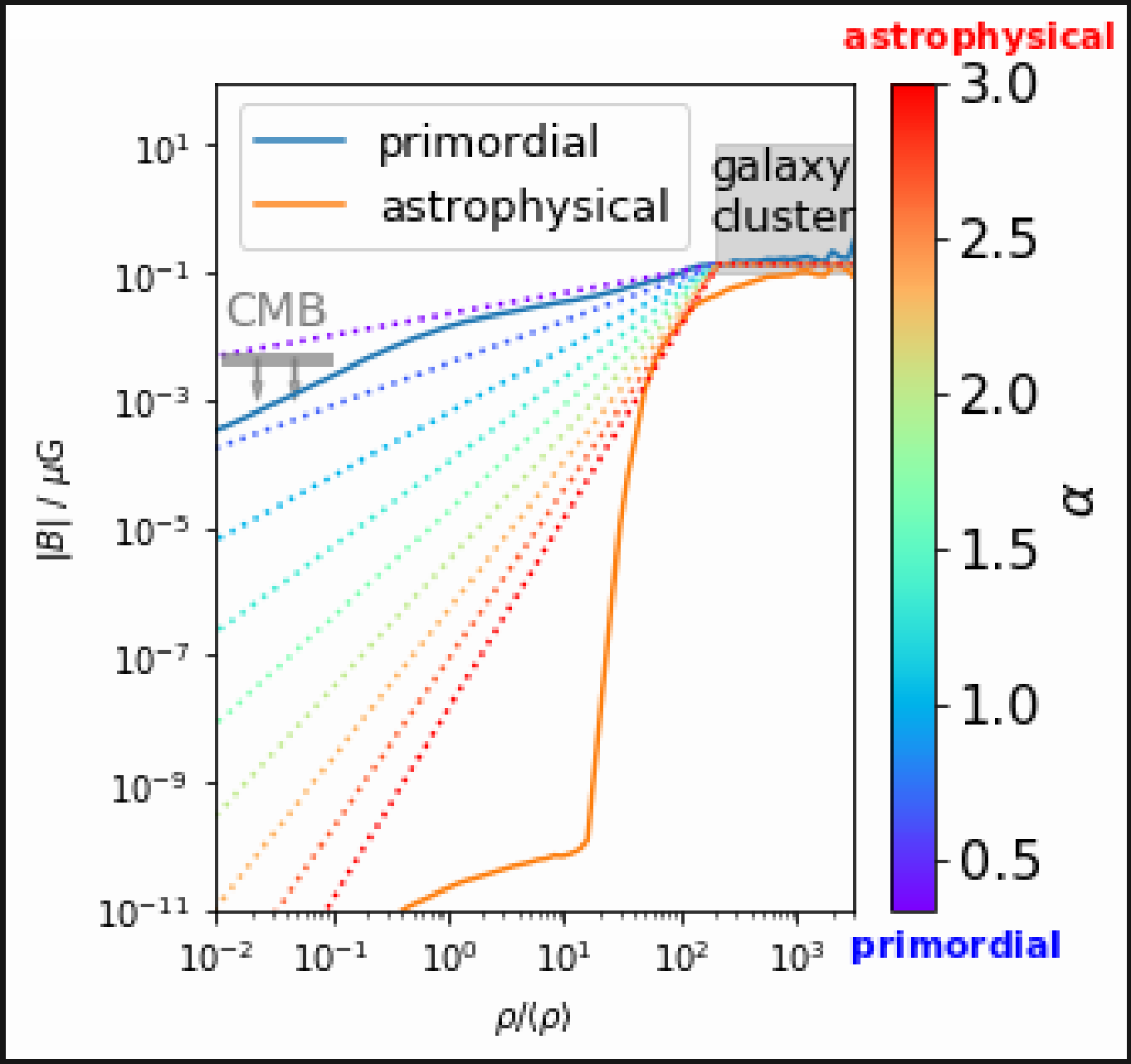
primordial astrophysical



Hackstein+ 2018, F. Vazza

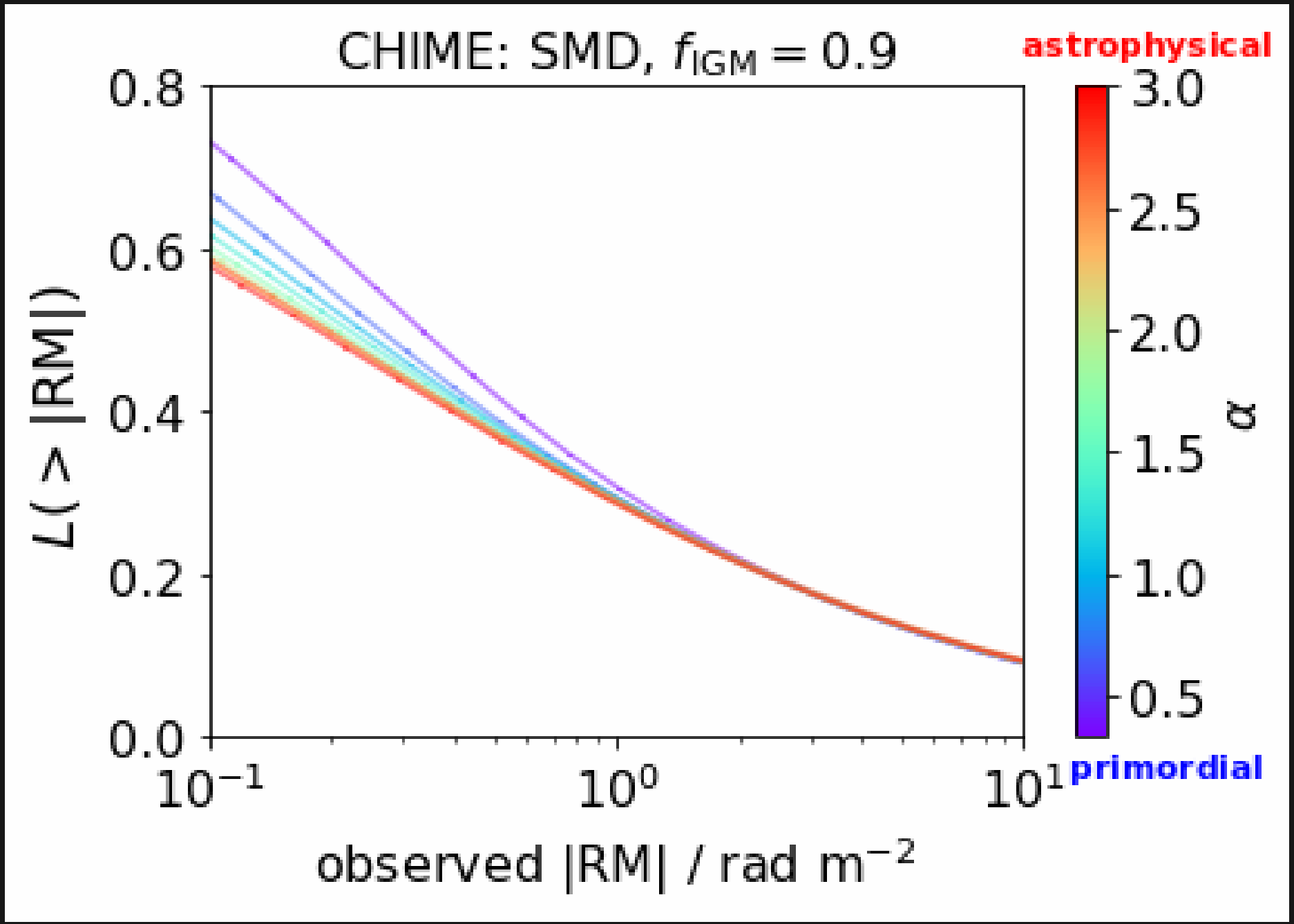


Hackstein et al. 2020



$B \propto \rho^{\alpha}$

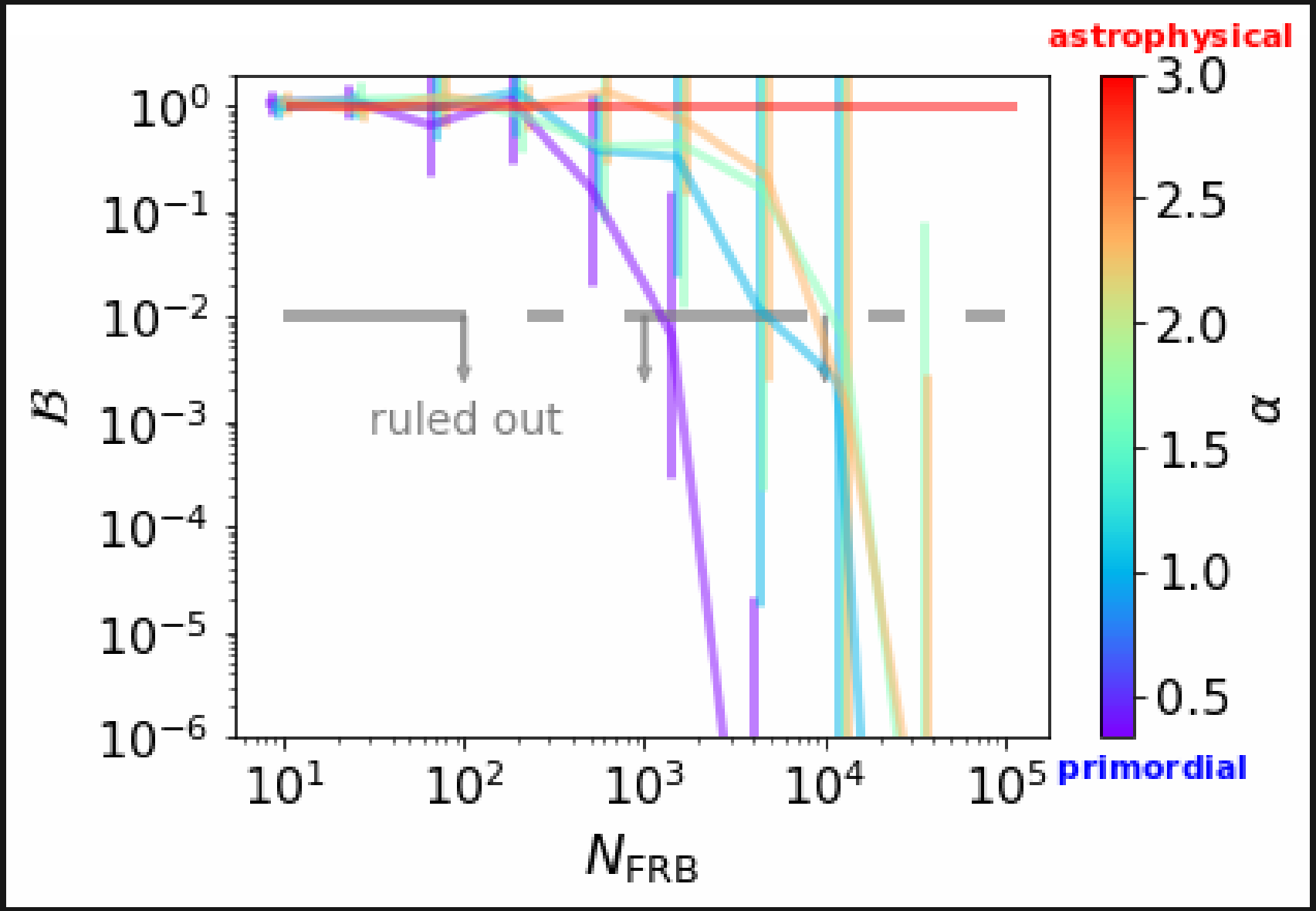
Hackstein et al. 2020



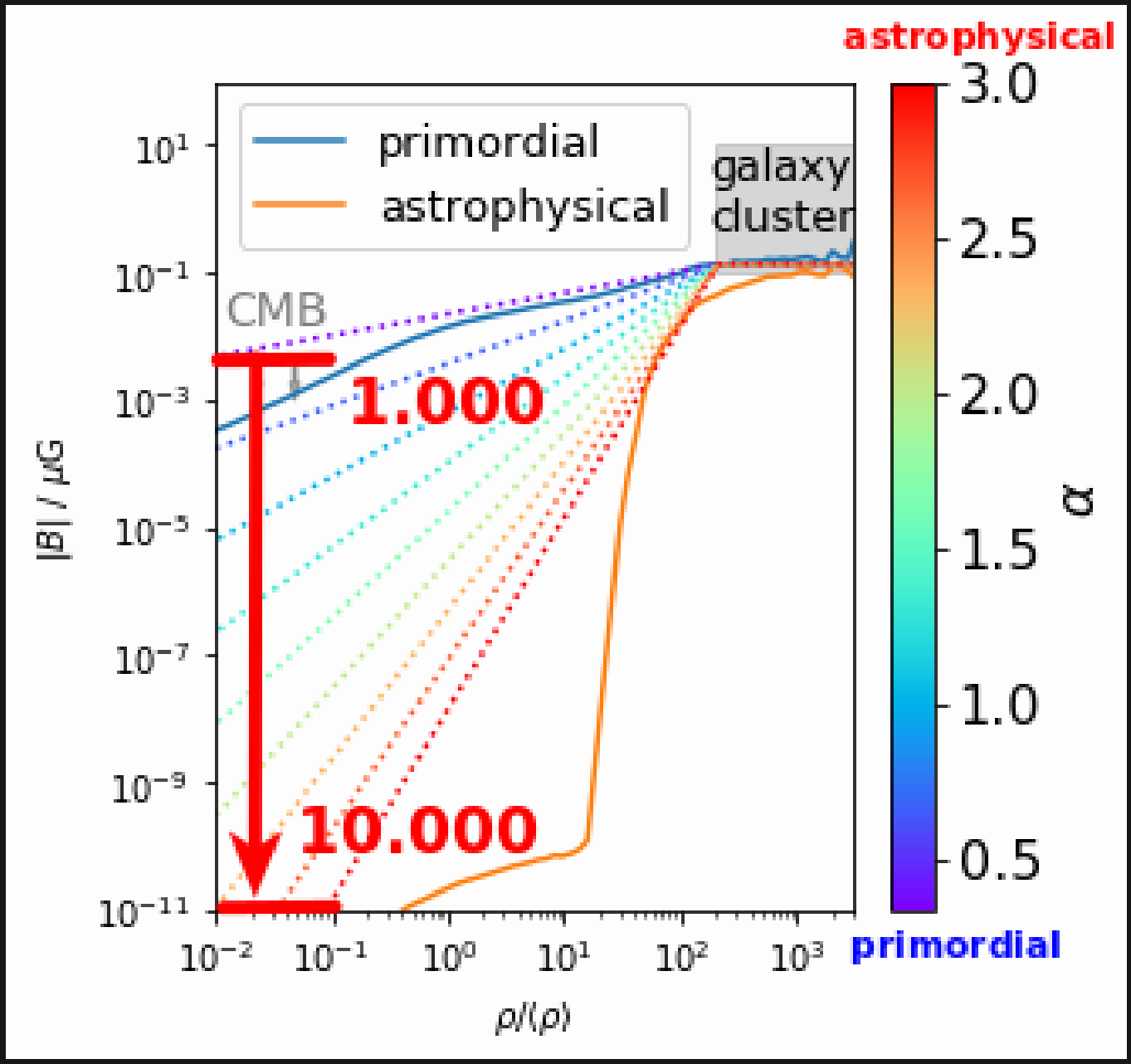
Hackstein et al. 2020

$$L(\mathrm{DM}, \mathrm{RM}) = \int \underbrace{L(\mathrm{RM}|z)}_{B_{\parallel}} \cdot \underbrace{L(\mathrm{DM}|z)\pi(z)}_{\text{redshift}} \mathrm{d}z$$

$\mathcal{B} = L(\alpha)/L(\alpha_0)$ $\quad L(\mathrm{DM},\mathrm{RM}) = \int \underbrace{L(\mathrm{RM}|z)}_{B_{||}} \cdot \underbrace{L(\mathrm{DM}|z)\pi(z)}_{\text{redshift}} \mathrm{d}z$



Hackstein et al. 2020



$B \propto \rho^{\alpha}$

Hackstein et al. 2020

PhD ✓

PostDoc . . .

stefan.hackstein@hs.uni-hamburg.de

Contributions

- FRBs $\rightarrow$measure IGMF & magneto-genesis
- PrEFRBLE way to interpret FRBs
  github.com/FRBs/PrEFRBLE
- consider all regions along LoS
- representative ensemble of galaxies