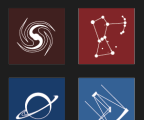
Update on the Cosmic String Project



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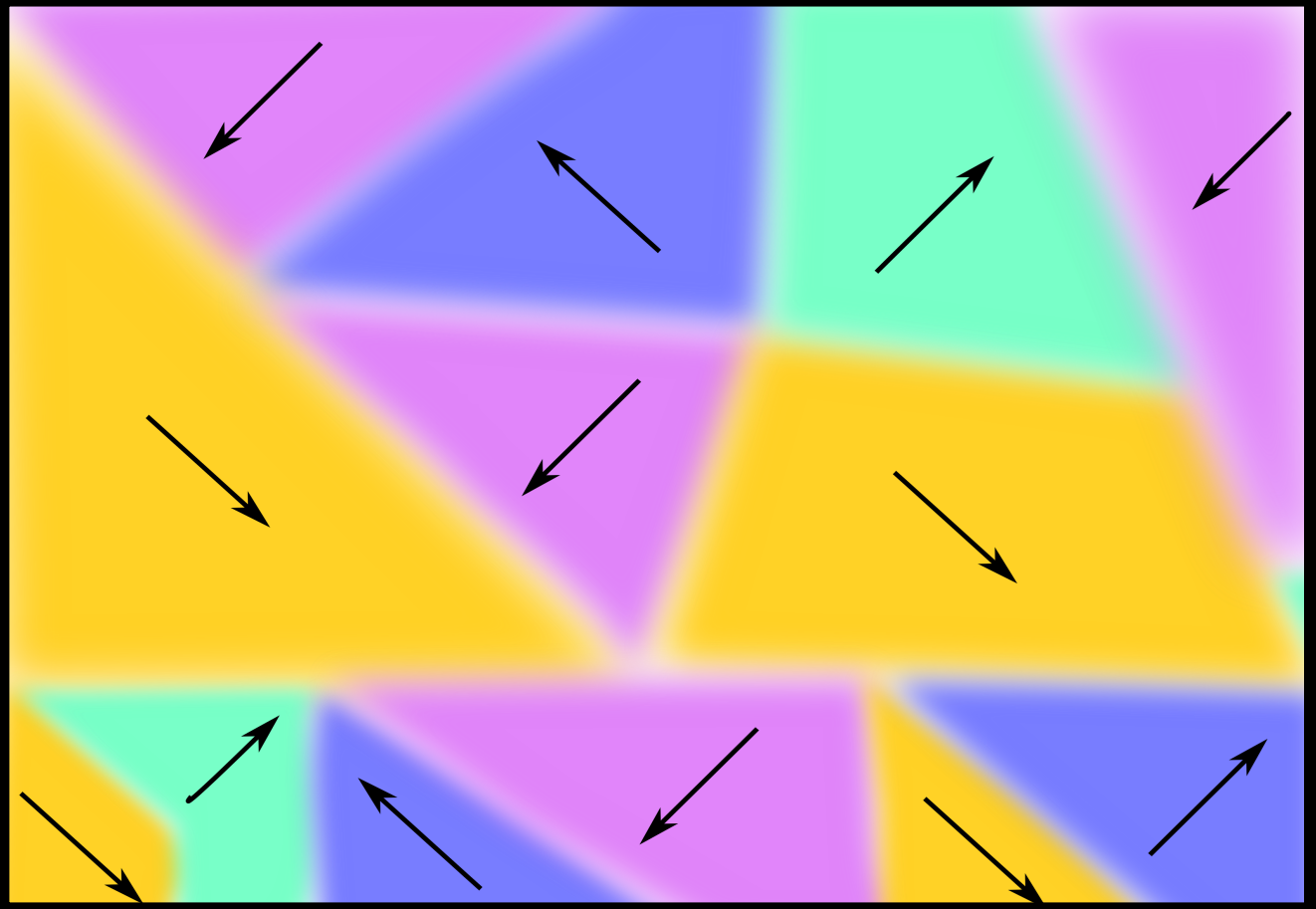
Cosmic Strings

SOMBRERO
POTENTIAL

Cosmic Strings

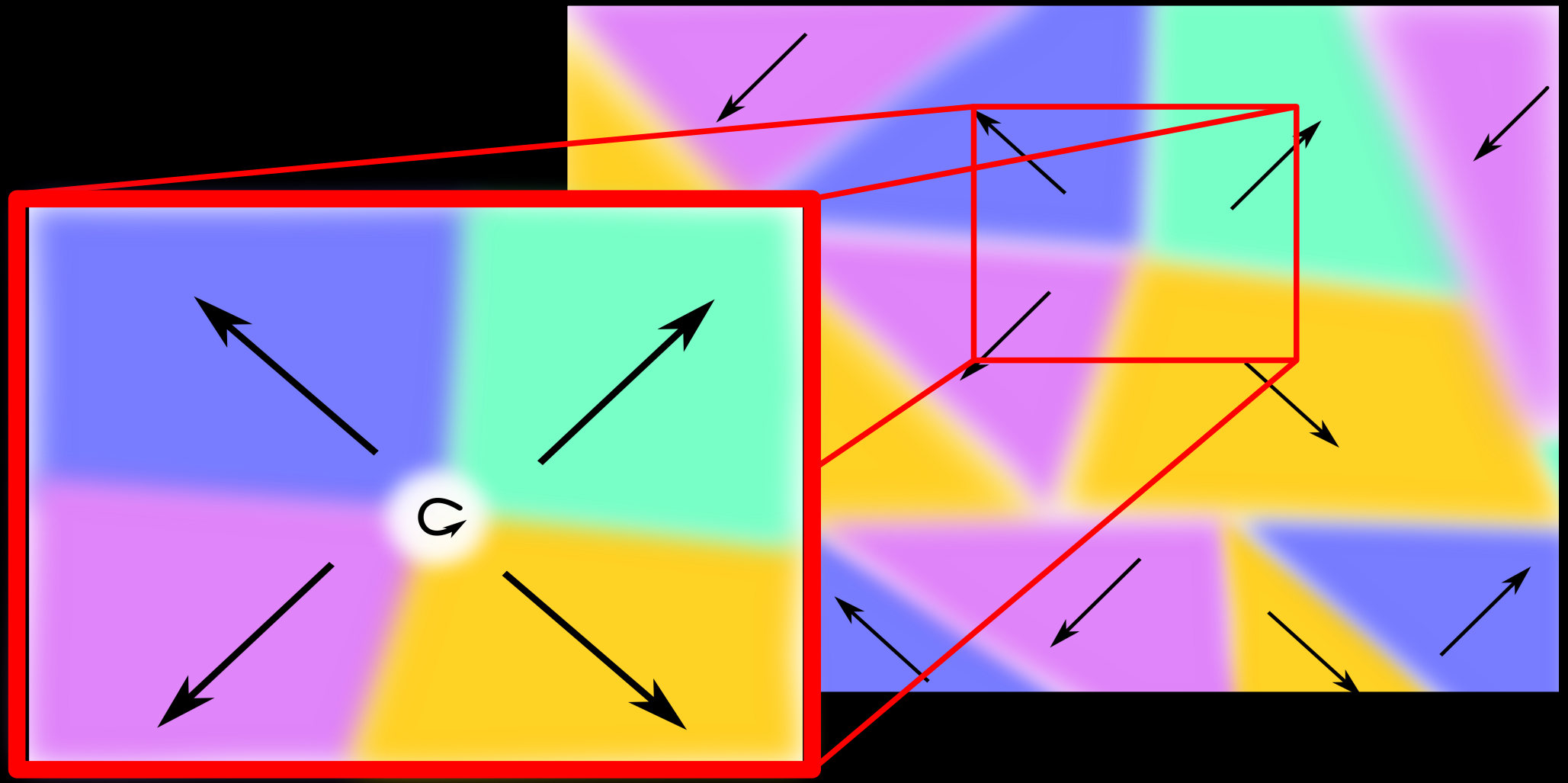
DIFFERENT PATCHES OF THE UNIVERSE FALL INTO DIFFERENT MINIMA!

SOMBRERO POTENTIAL

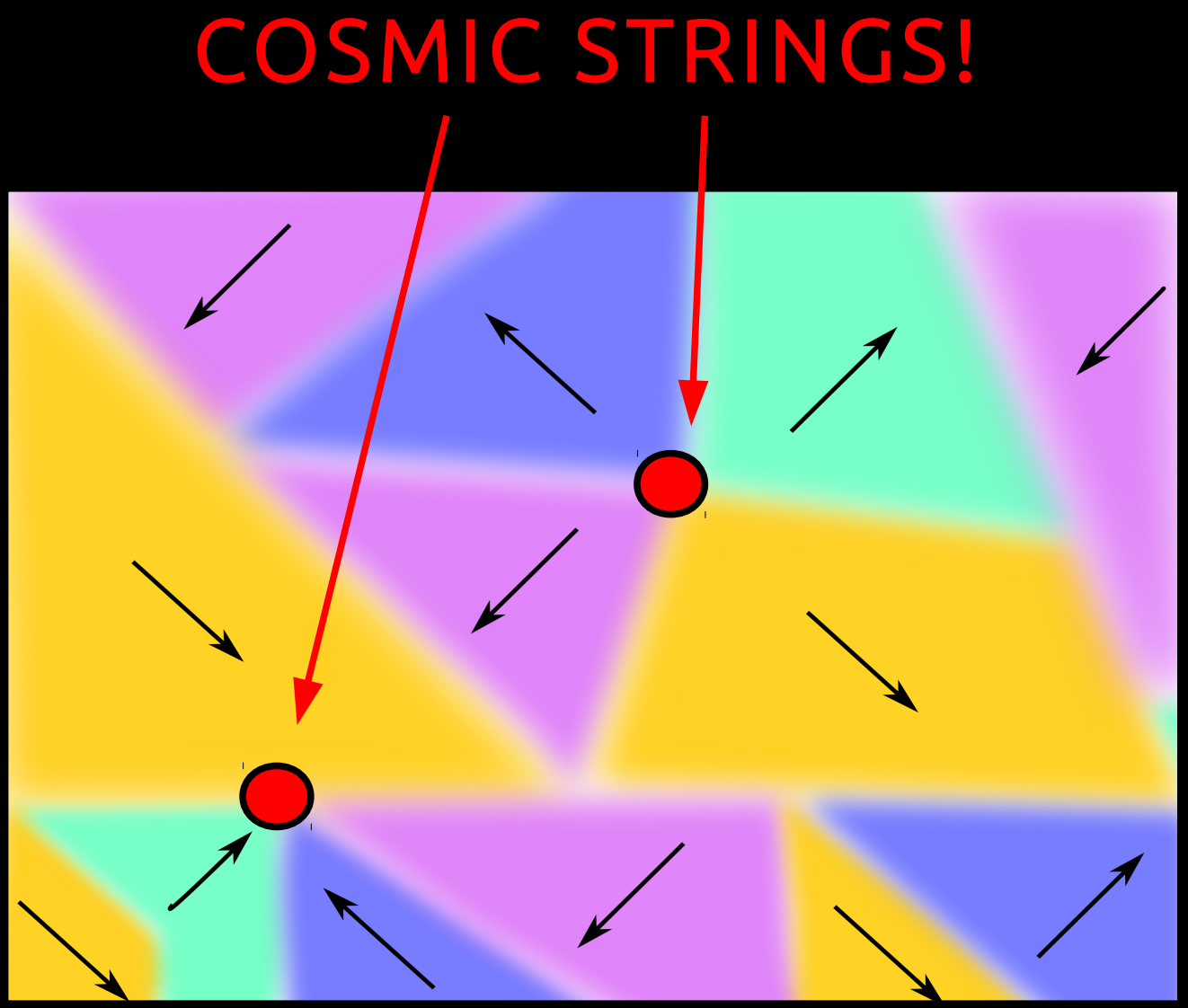


Cosmic Strings

WHAT LURKS IN THE EDGES?

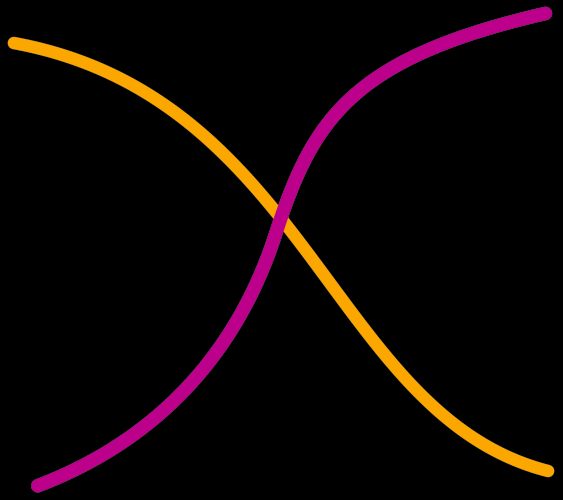


Cosmic Strings



String Interactions

UPON COLLISION…



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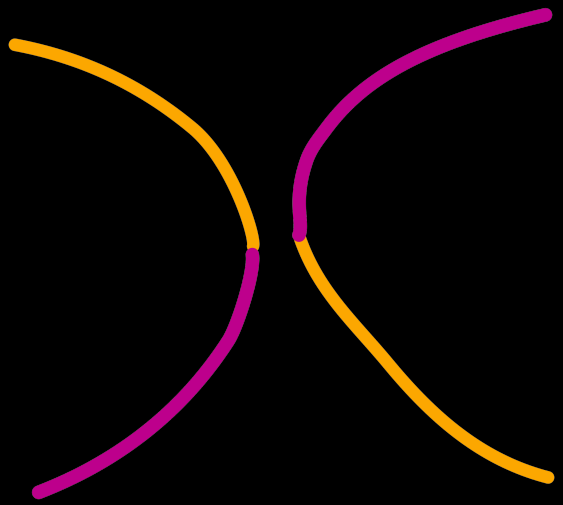

...STRINGS EXCHANGE PARTNERS AND RECONNECT!

String Interactions

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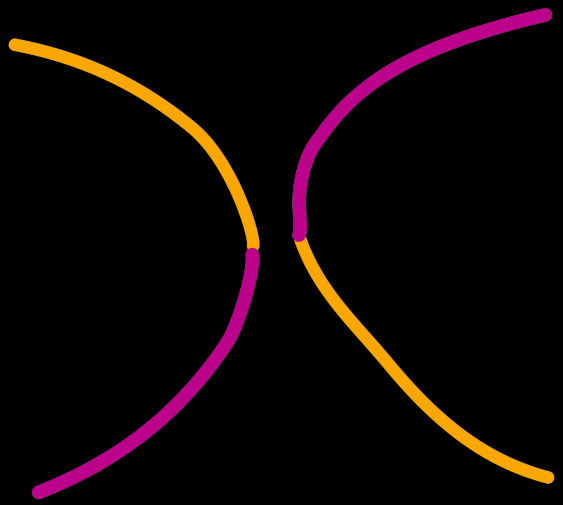

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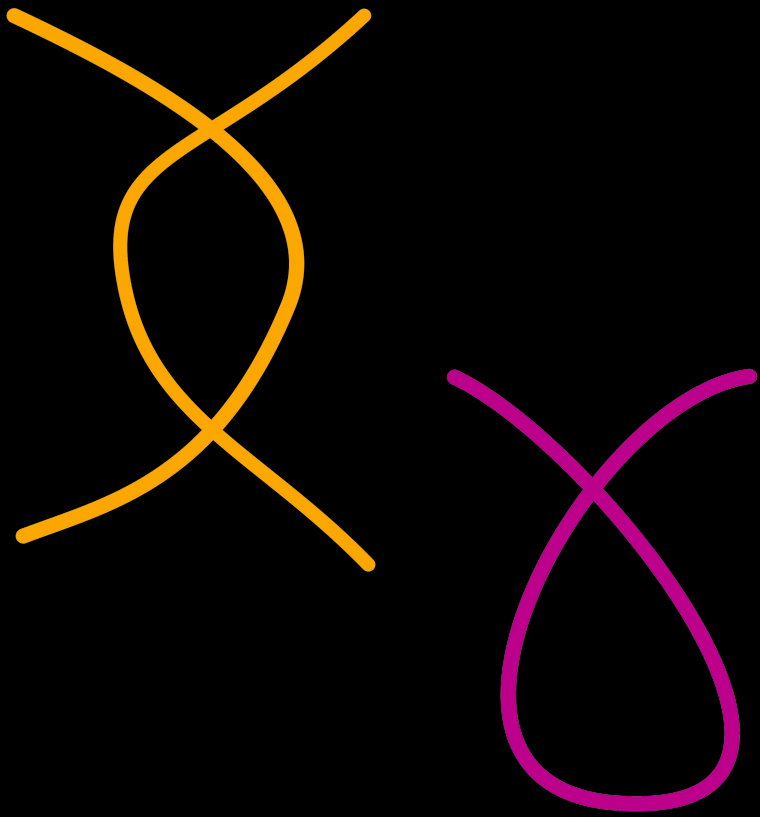

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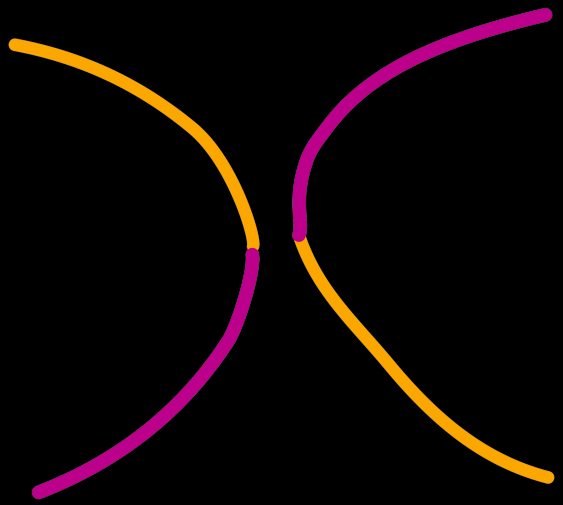


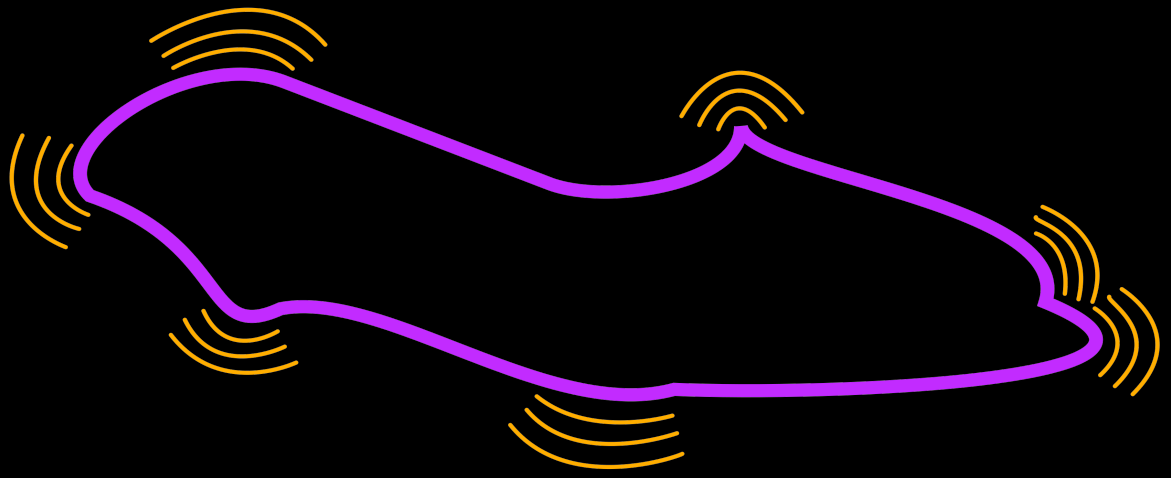
...STRINGS EXCHANGE PARTNERS AND RECONNECT!

BUT IN SOME SITUATIONS,

COSMIC STRING LOOPS ARE CREATED!

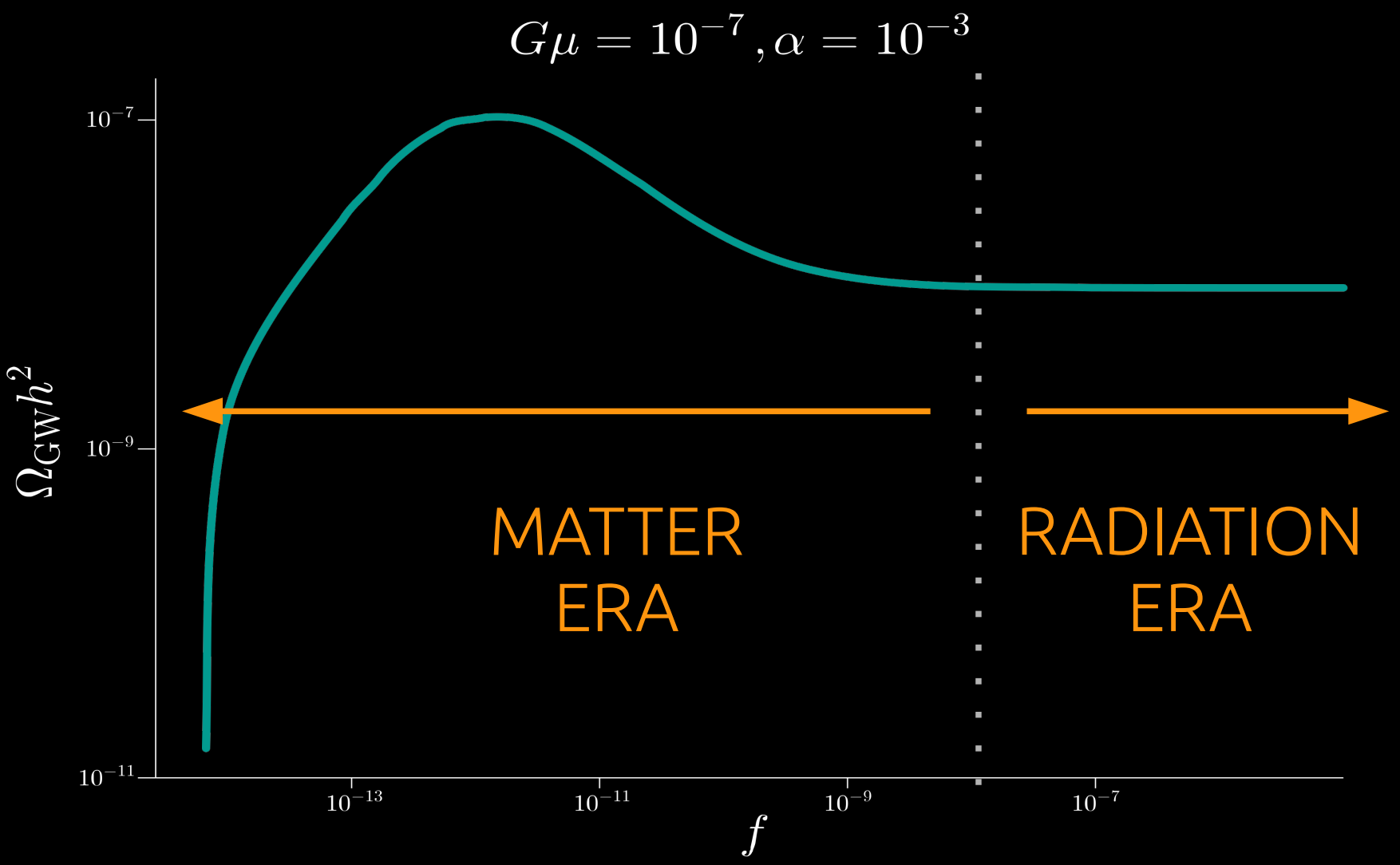
Loops & Gravitational Waves

LOOPS RADIATE GRAVITATIONAL WAVES



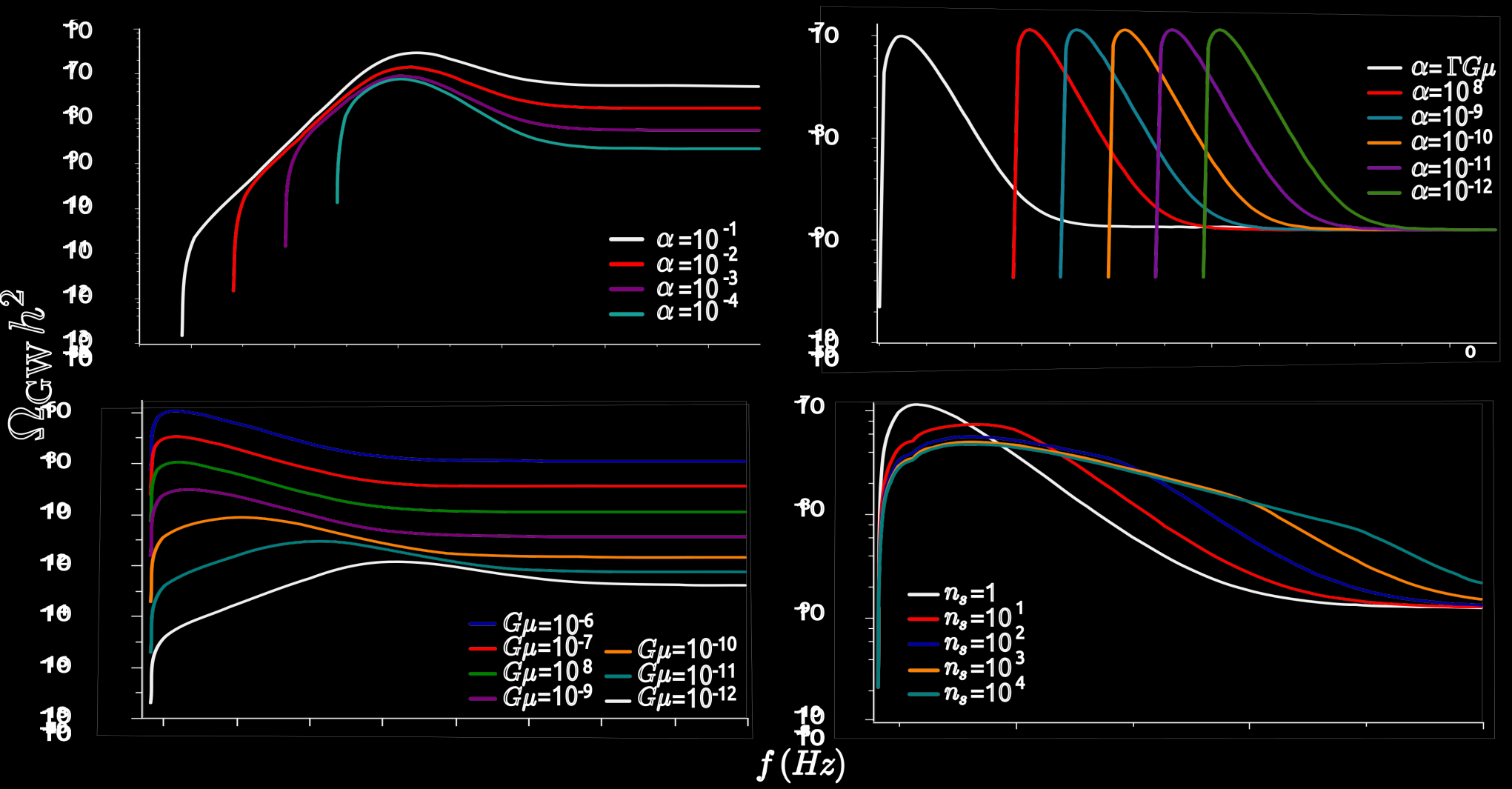
AND ARE COPIOUSLY CREATED
THROUGHOUT COSMOLOGICAL HISTORY.

Typical SGWB Spectrum



SGWB: Cosmic Strings

THE SPECTRUM MAY LOOK VERY DIFFERENTLY…



GW Emission by Loops

GWs are emitted at a constant rate:

$$P = \Gamma G \mu^2$$

Frequency is determined by the length of loops:

$$f = \frac{2n}{\ell}, \text{ with } \ell(t) = \ell_0 - \Gamma G \mu (t - t_0)$$

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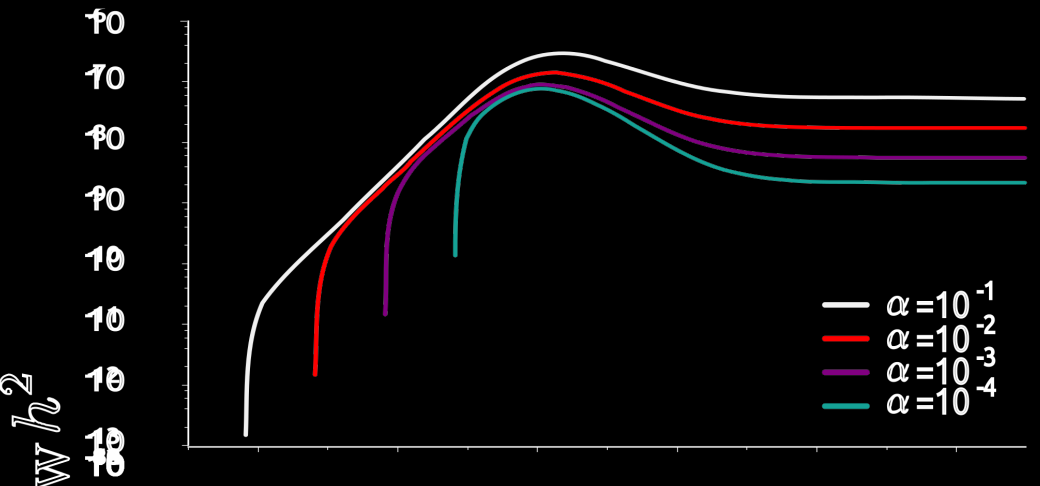
The shape of the SGWB depends both on macroscopic and microscopic parameters

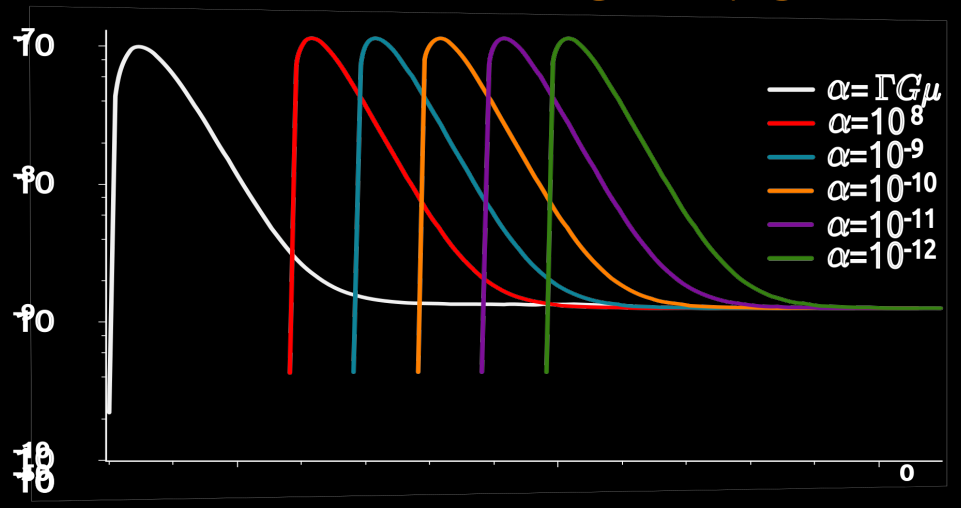
SGWB: Cosmic Strings

THE SPECTRUM MAY LOOK VERY DIFFERENTLY...

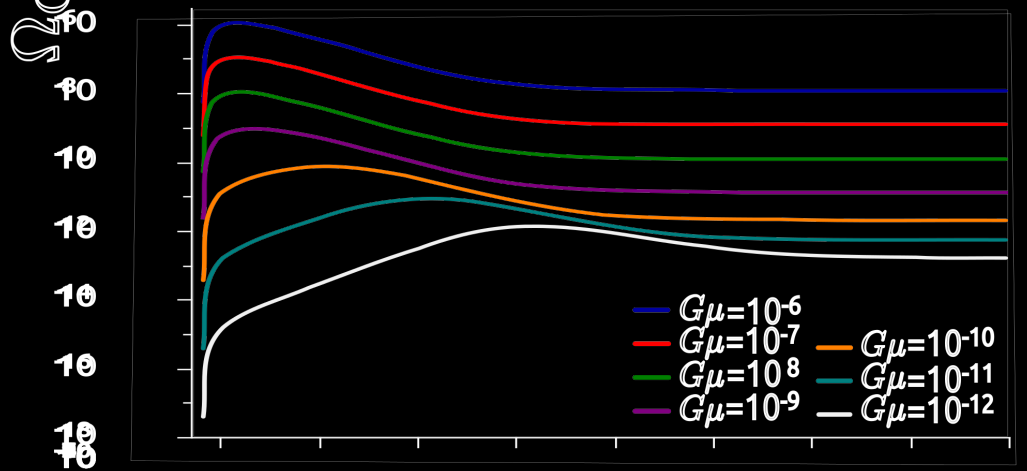
DIFFERENT SIZE: LARGE



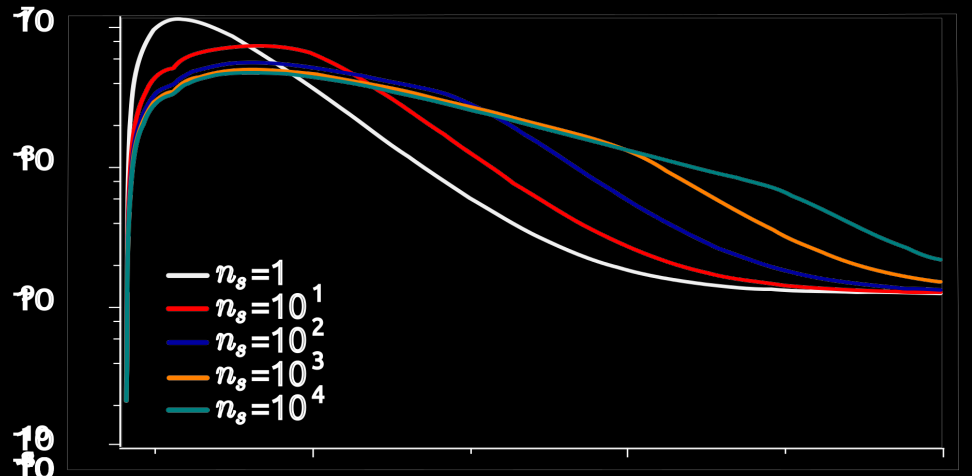
DIFFERENT SIZE: SMALL



$\Omega_{GW}h^2$



DIFFERENT TENSION



$f\,(Hz)$

DIFFERENT EMISSION SPECTRUM

SGWB: Cosmic Strings

TO ACCURATELY CHARACTERISE THE SGWB ONE NEEDS TO DETERMINE THE LOOP DISTRIBUTION FUNCTION $n(\ell(t), t)$

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EFFICIENCY OF LOOP-CHOPPING MECHANISM

LOOP SIZE

EMISSION SPECTRUM

SIMULATIONS: NAMBU- GOTO

* INFINITELY THIN AND FEATURELESS STRINGS
* NO BACK-REACTION

10% OF THE ENERGY GOES INTO **LARGE LOOPS**:

$$\ell(t) \approx 0.1t$$

(the rest goes into small loops with high peculiar velocities)

Simulations: Field- Theory

* MAIN ENERGY LOSS MECHANISM SEEM TO BE THE EMISSION OF SCALAR AND GAUGE RADIATION;
* EMISSION OF GWS IS REDUCED;

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* MAIN ENERGY LOSS MECHANISM SEEM TO BE THE EMISSION OF SCALAR AND GAUGE RADIATION;
* EMISSION OF GWS IS REDUCED;

NO EVIDENCE FOR SIGNIFICANT (LARGE) STABLE LOOP PRODUCTION...

Simulations: To Sum Up

THE GOOD

BOTH (MORE OR LESS) AGREE ON THE LARGE SCALE DYNAMICS OF COSMIC STRING NETWORK

THE BAD

THEY ARE IN COMPLETE DISAGREEMENT ABOUT THE MAIN MECHANISM OF ENERGY LOSS

Simulations: To Sum Up

THE GOOD

BOTH (MORE OR LESS) AGREE ON THE LARGE SCALE DYNAMICS OF COSMIC STRING NETWORK

THE BAD

THEY ARE IN COMPLETE DISAGREEMENT ABOUT THE MAIN MECHANISM OF ENERGY LOSS

THE UGLY

IT IS NOT CLEAR WHETHER THESE “DIFFERENCES” WILL BE SETTLED SOON…

Semi-Analytical Models

* PARAMETRIC APPROACH: LOOP SIZE & AMOUNT OF ENERGY THAT GOES INTO GW ARE TREATED AS FREE PARAMETERS;
* BASED ON ANALYTICAL MODELS (OS,VOS) TO DESCRIBE LARGE-SCALE EVOLUTION OF THE NETWORKS;

ALLOW FOR THE CONSTRUCTION OF THE LOOP DISTRIBUTION FUNCTION FOR SEVERAL SCENARIOS

Cosmic Strings Project

(As defined in the 4th LISA Cosmology WG Workshop)

(A)Forecast constraints on cosmic string tension based for

(i) NAMBU-GOTO SIMULATIONS
(ii) “AGNOSTIC” INVESTIGATIONS
(iii) NETWORKS WITHOUT SIGNIFICANT LOOP PRODUCTION

(B) Comparative analysis of different models

[(C) Cosmic superstrings]

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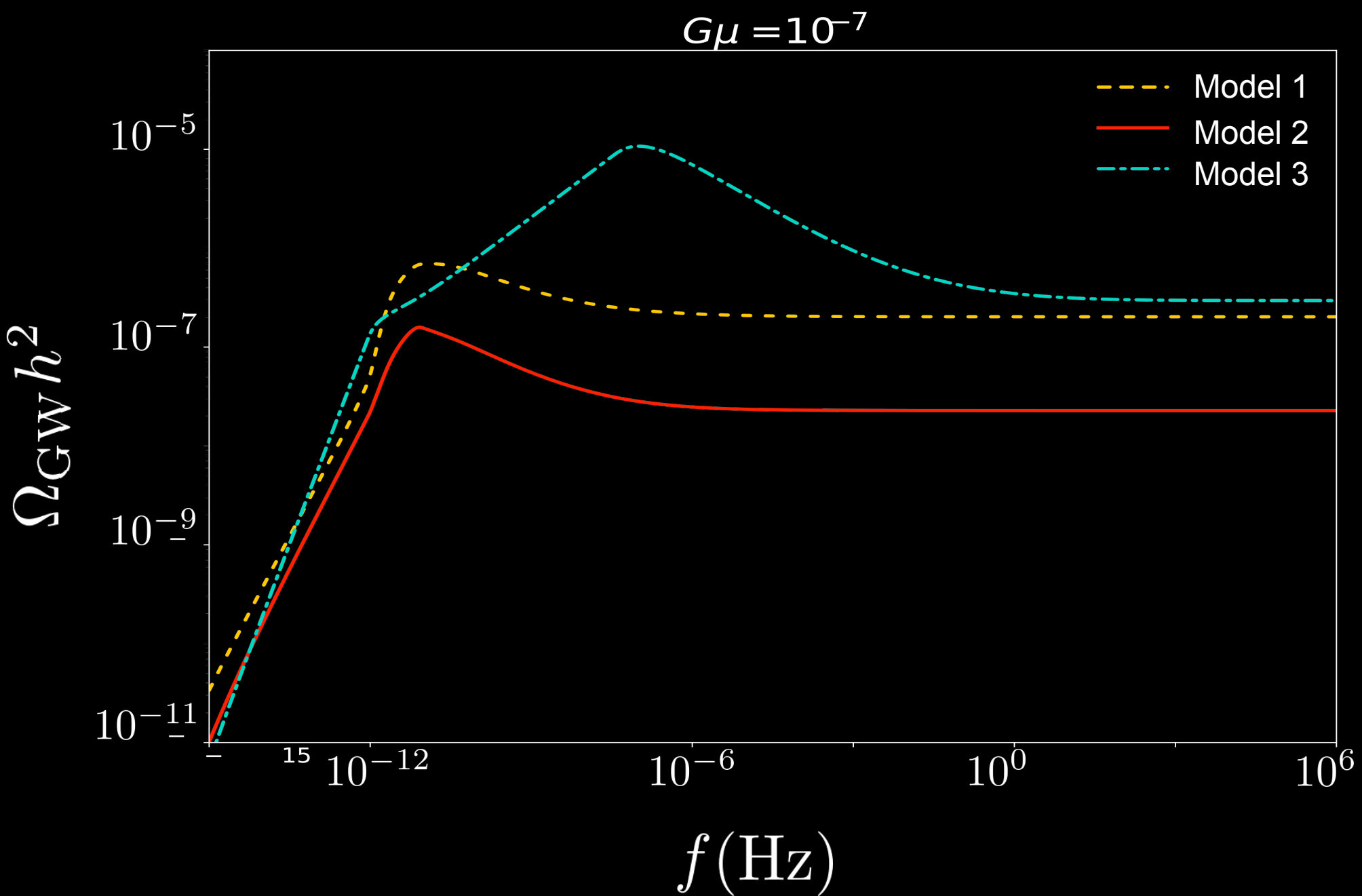
Model Comparison

MODEL 1	MODEL 2	MODEL 3
"AGNOSTIC" APPROACH: LOOP SIZE IS FREE PARAMETER	10% OF THE ENERGY GOES INTO LARGE LOOPS	LARGE NUMBER OF SMALL LOOPS

CALIBRATED USING SIMULATIONS

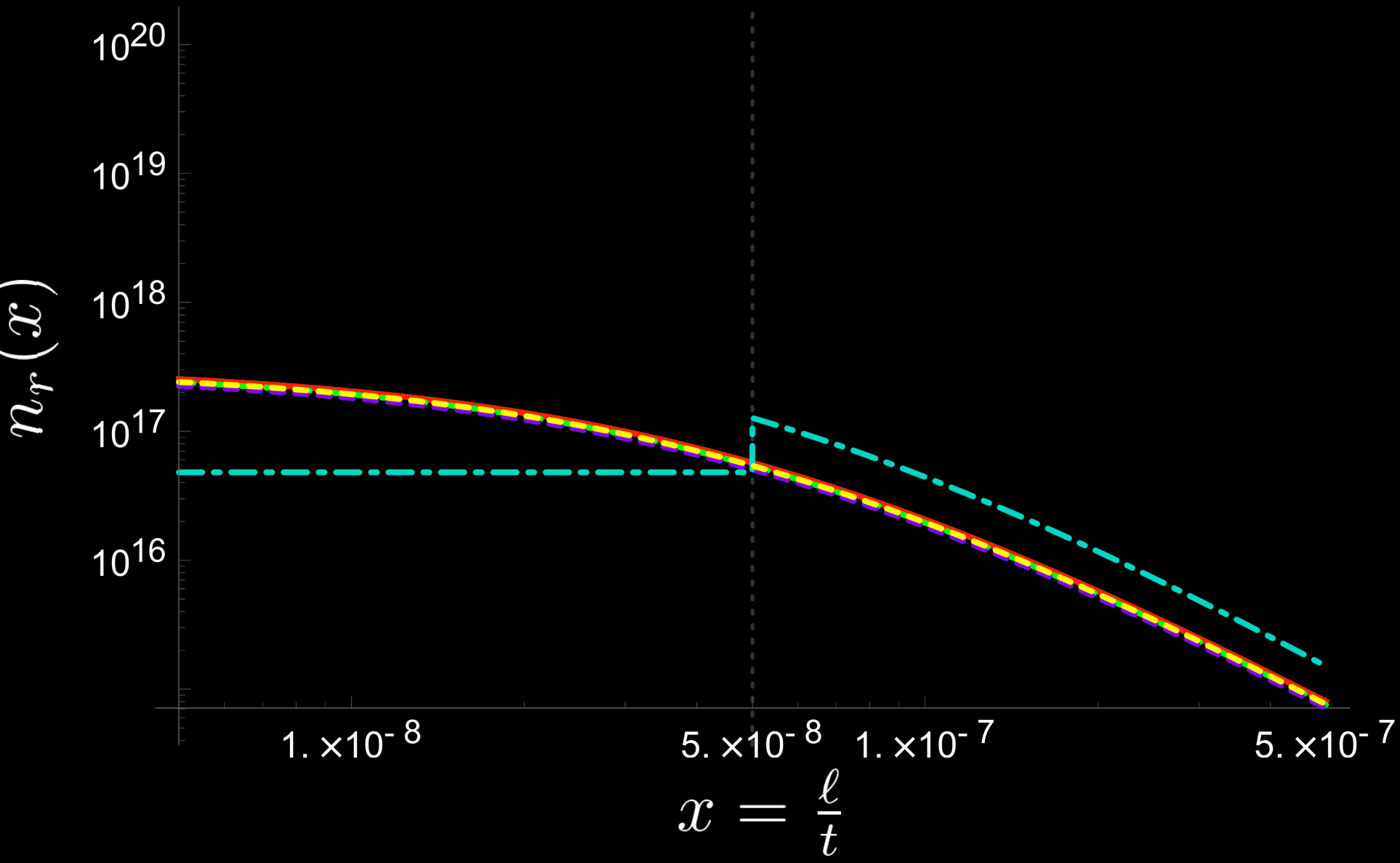
CONSTRUCTED USING NAMBU-GOTO SIMULATIONS

Model Comparison



Model Comparison

NUMBER DENSITY OF LOOPS IN THE RADIATION ERA



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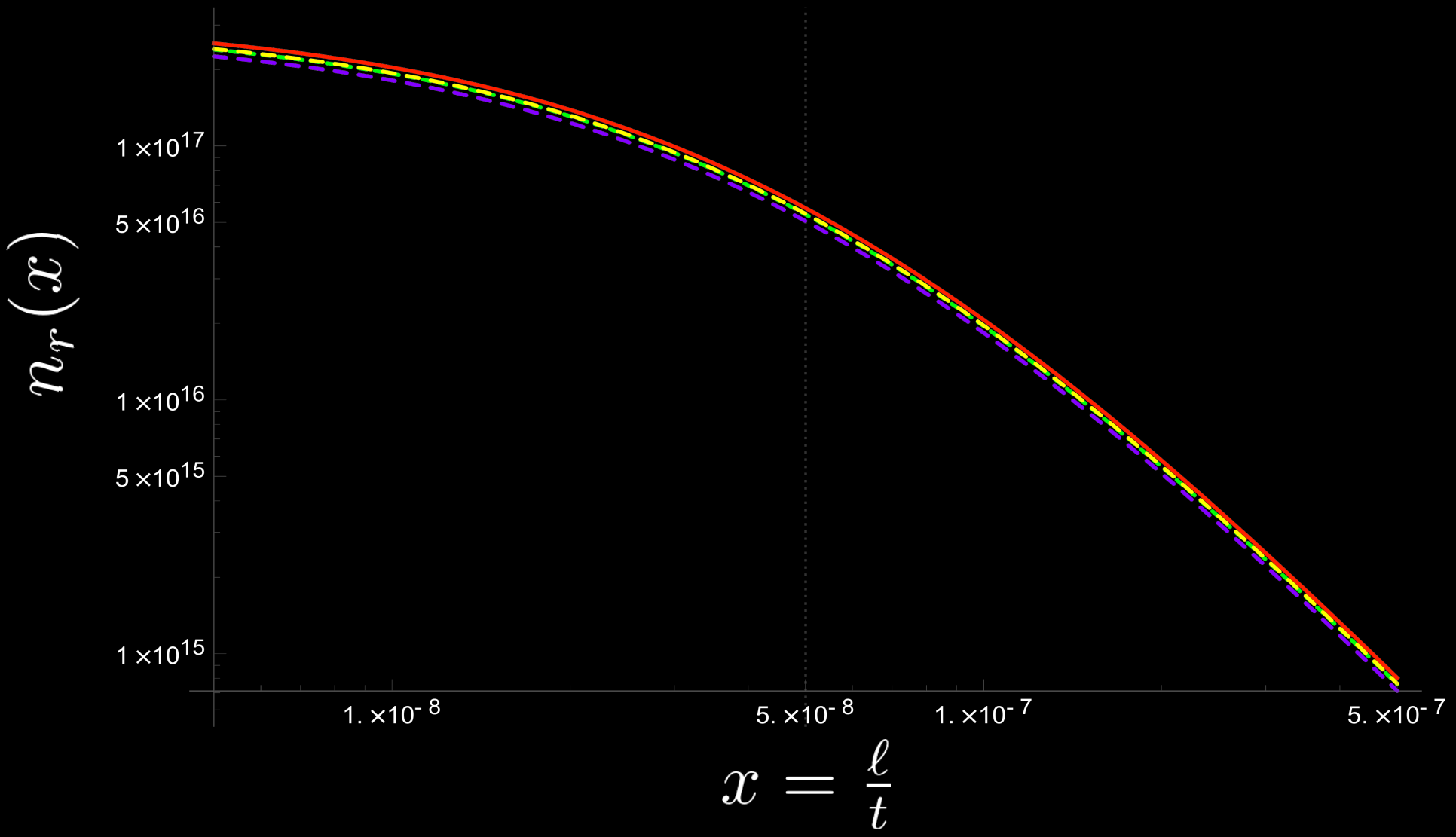

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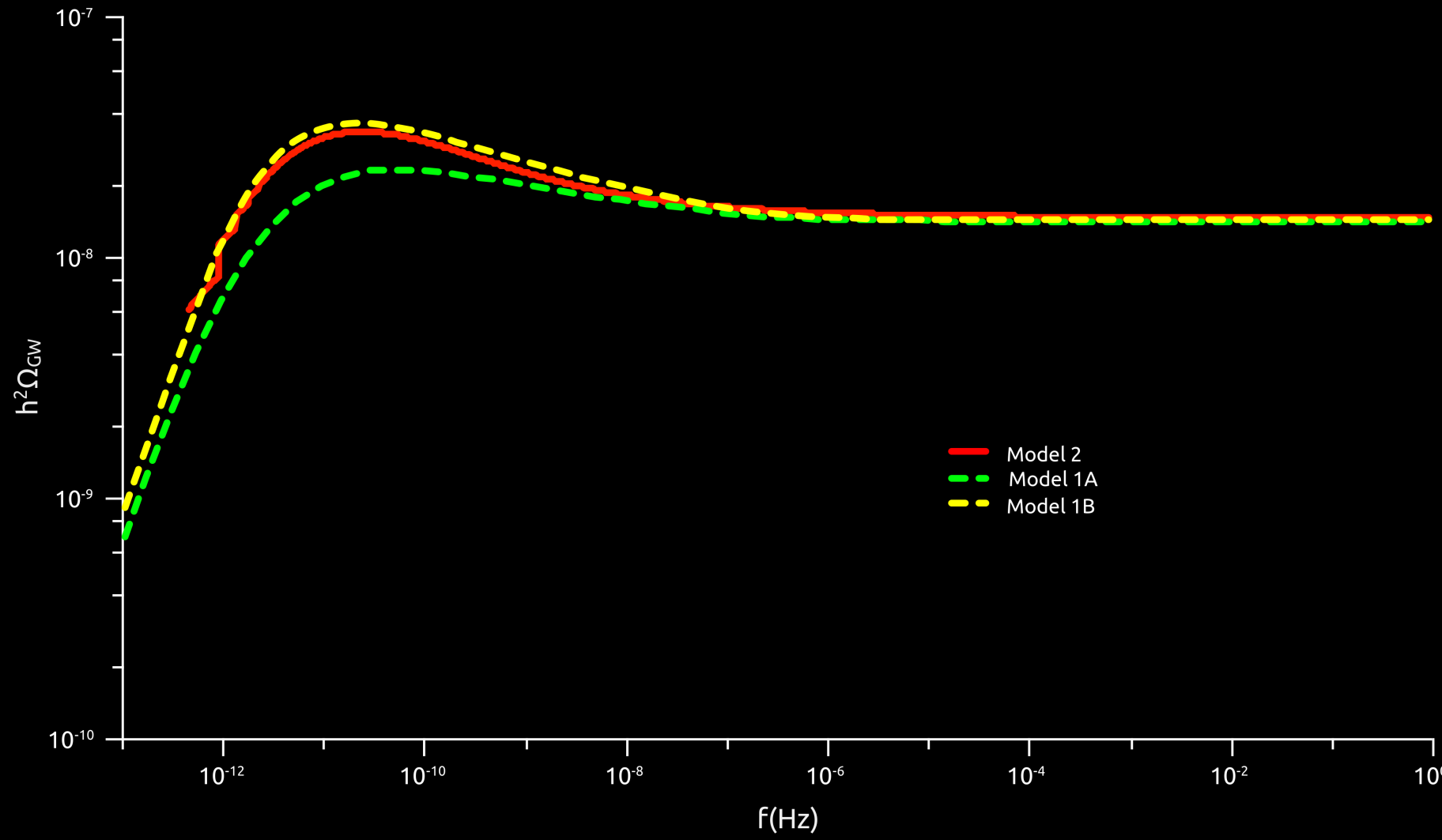
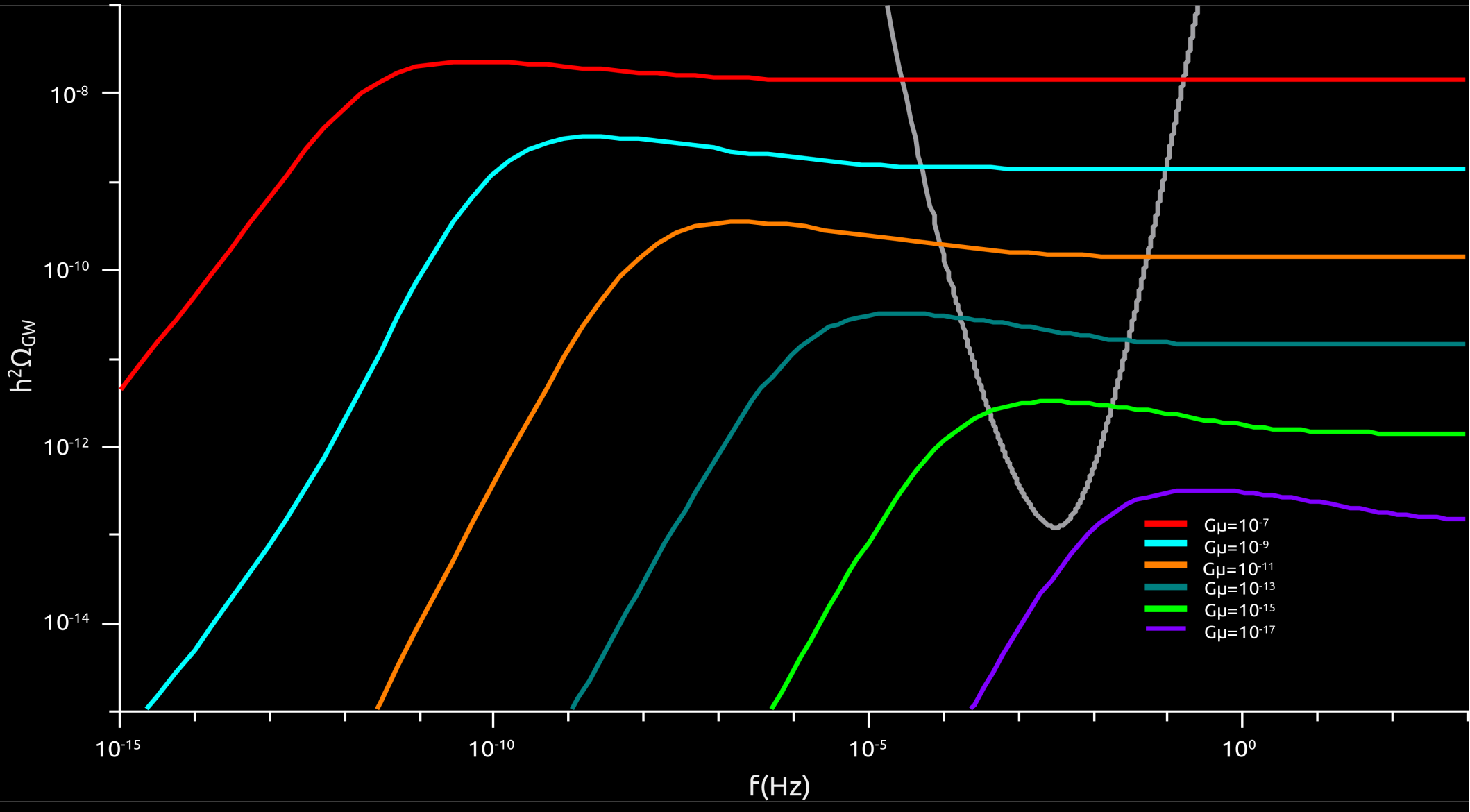


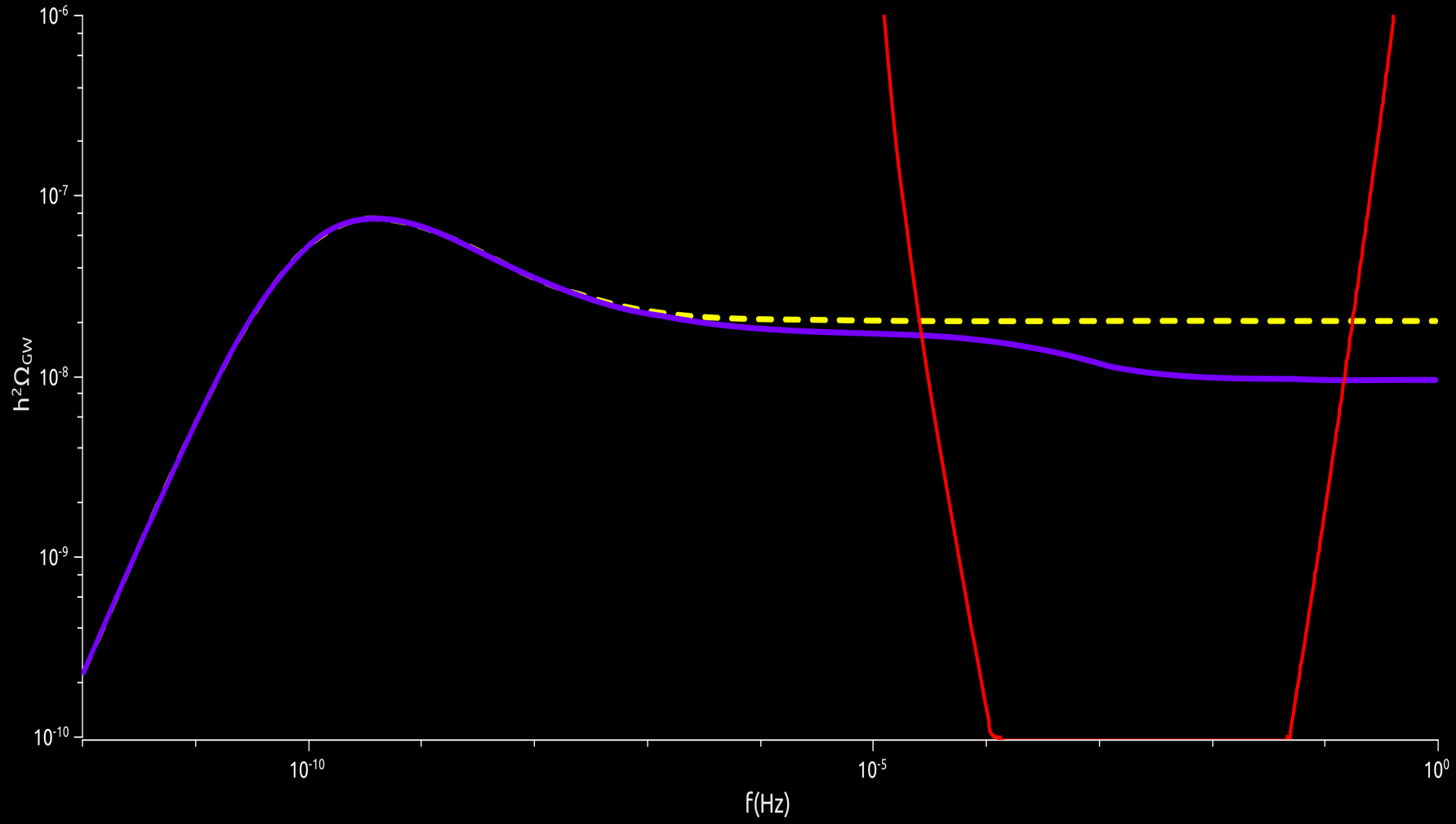
What Can LISA See?

FOR NAMBU-GOTO STRINGS: $G\mu \sim \mathcal{O}(10^{-16} - 10^{-17})$



What Can LISA See?

PARTICLE ANNIHILATION:



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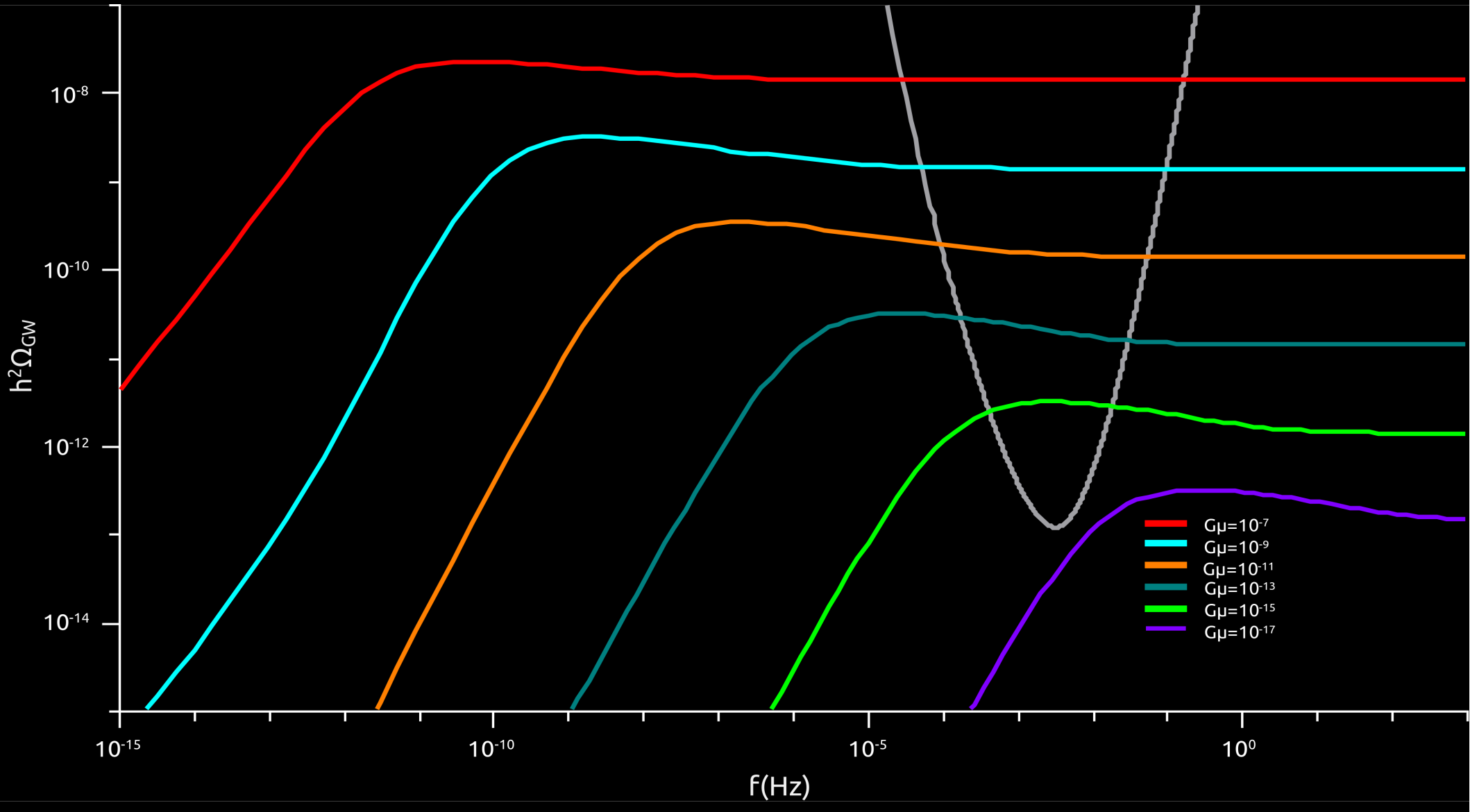
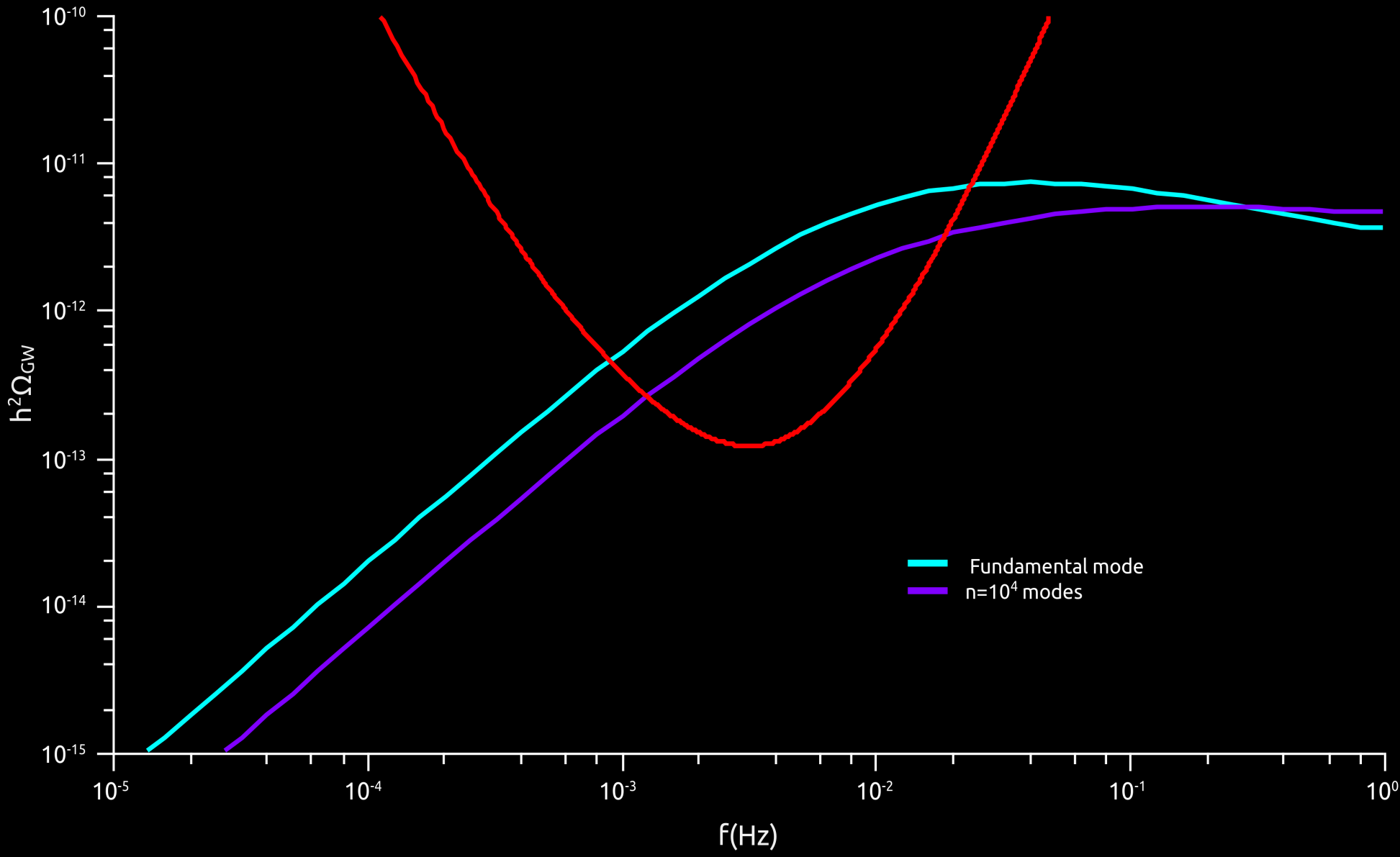


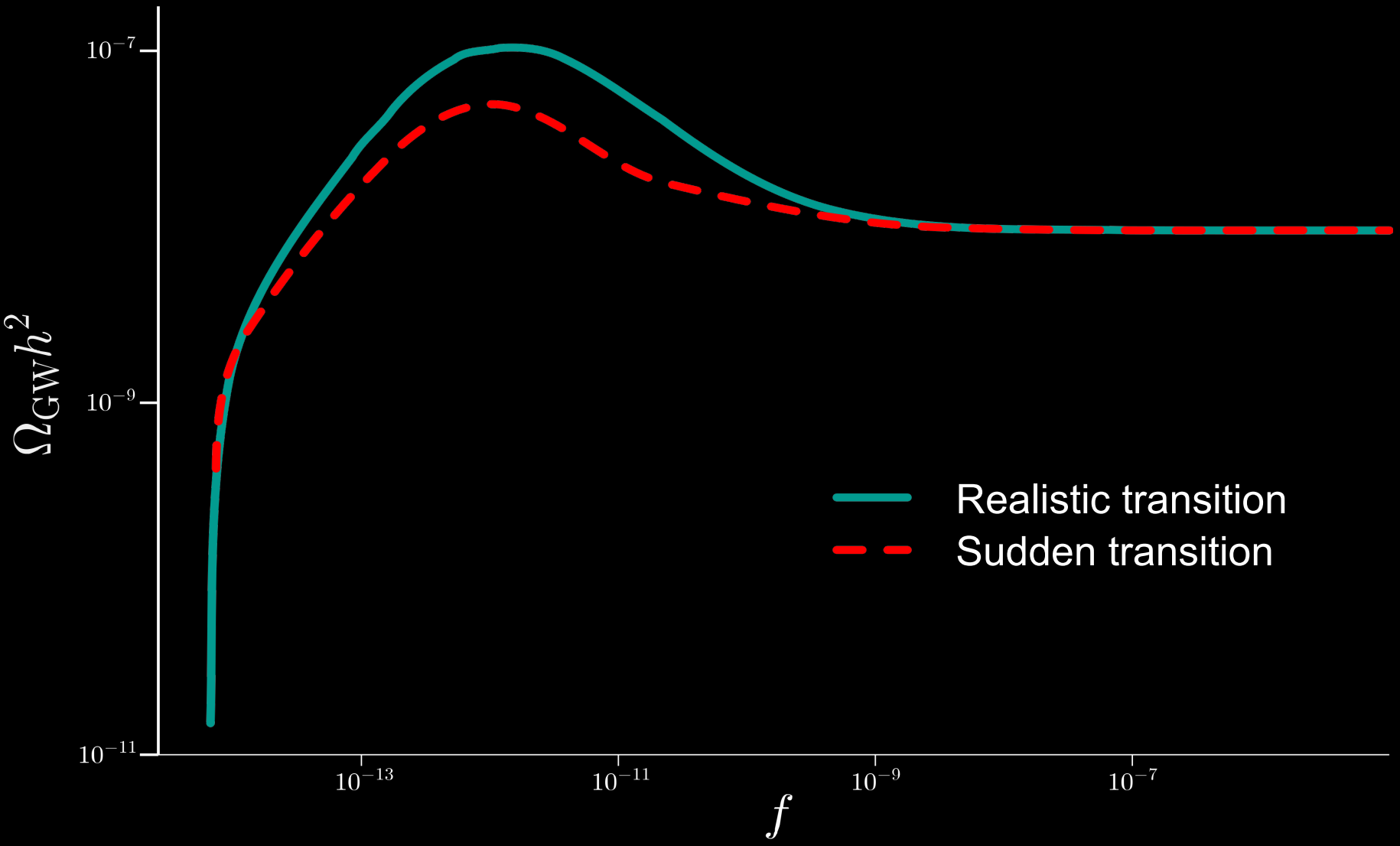
What Can LISA See?

EMISSION SPECTRUM OF LOOPS



What Can LISA See?

RADIATION MATTER TRANSITION



To Sum Up

THE SPECTRA GENERATED BY COSMIC STRINGS FALLS NATURALLY INTO THE LISA WINDOW!

BEFORE JUMPING INTO FORECASTS:
*WE ARE VERIFYING THE CONSISTENCY OF THE MODELS;
*WE ARE IDENTIFYING THE RELEVANT PHYSICAL PROCESSESES THAT MAY HAVE AN IMPACT ON THE SHAPE OF THE SGWB;

HOPEFULLY THIS SHALL RESULT IN MORE ROBUST AND TRUSTWORTHY CONSTRAINTS.
STAY TUNED!

THANK YOU!