Regularization-Independent Inflaton Spectrum

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With Leonard Parker

Supported by Lynde and Harry Bradley Foundation and Wisconsin Space Grant Consortium

UWM UNIVERSITY of WISCONSIN MILWAUKEE

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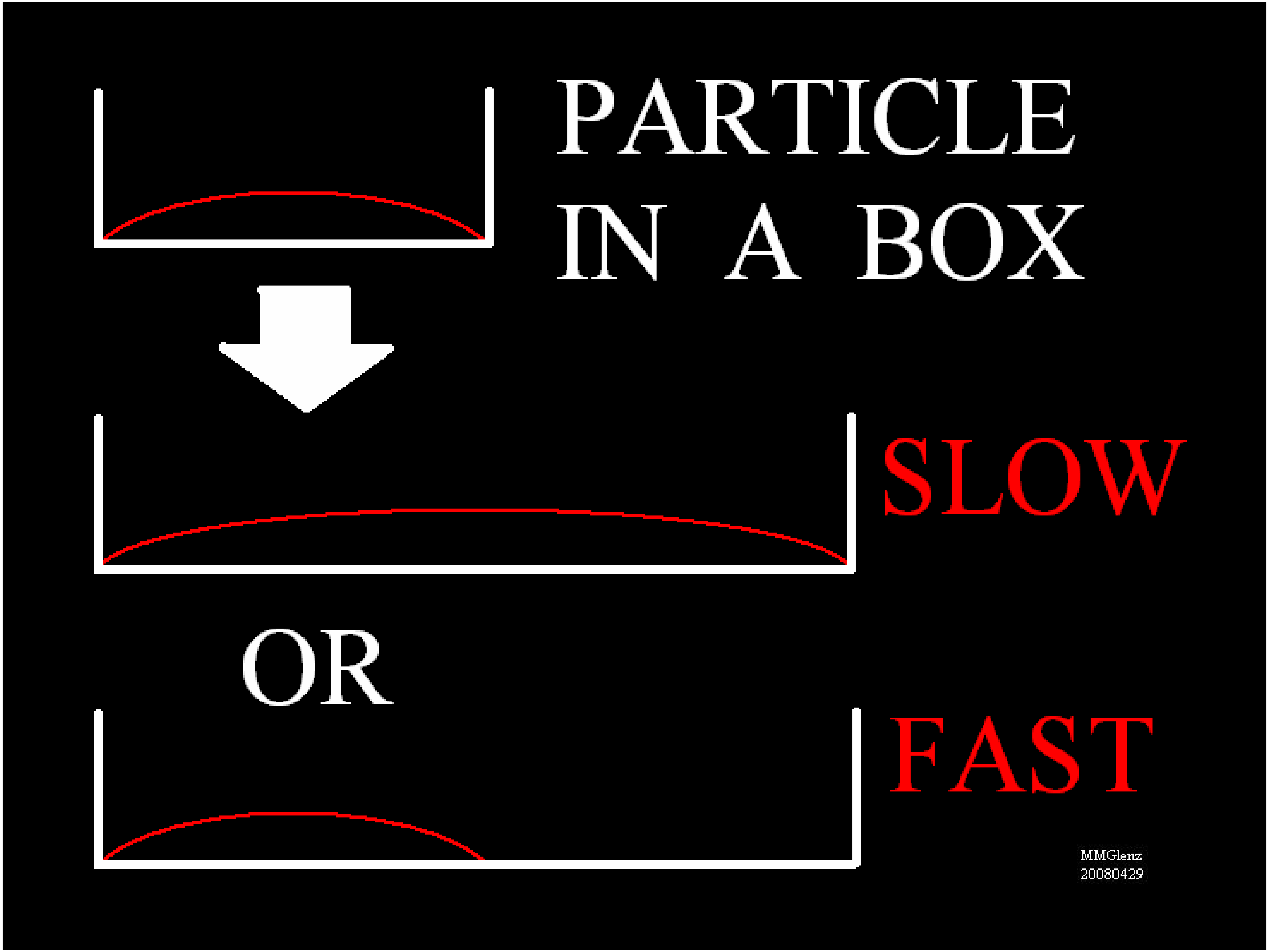
PARTICLE
IN A BOX
SLOW
OR
FAST
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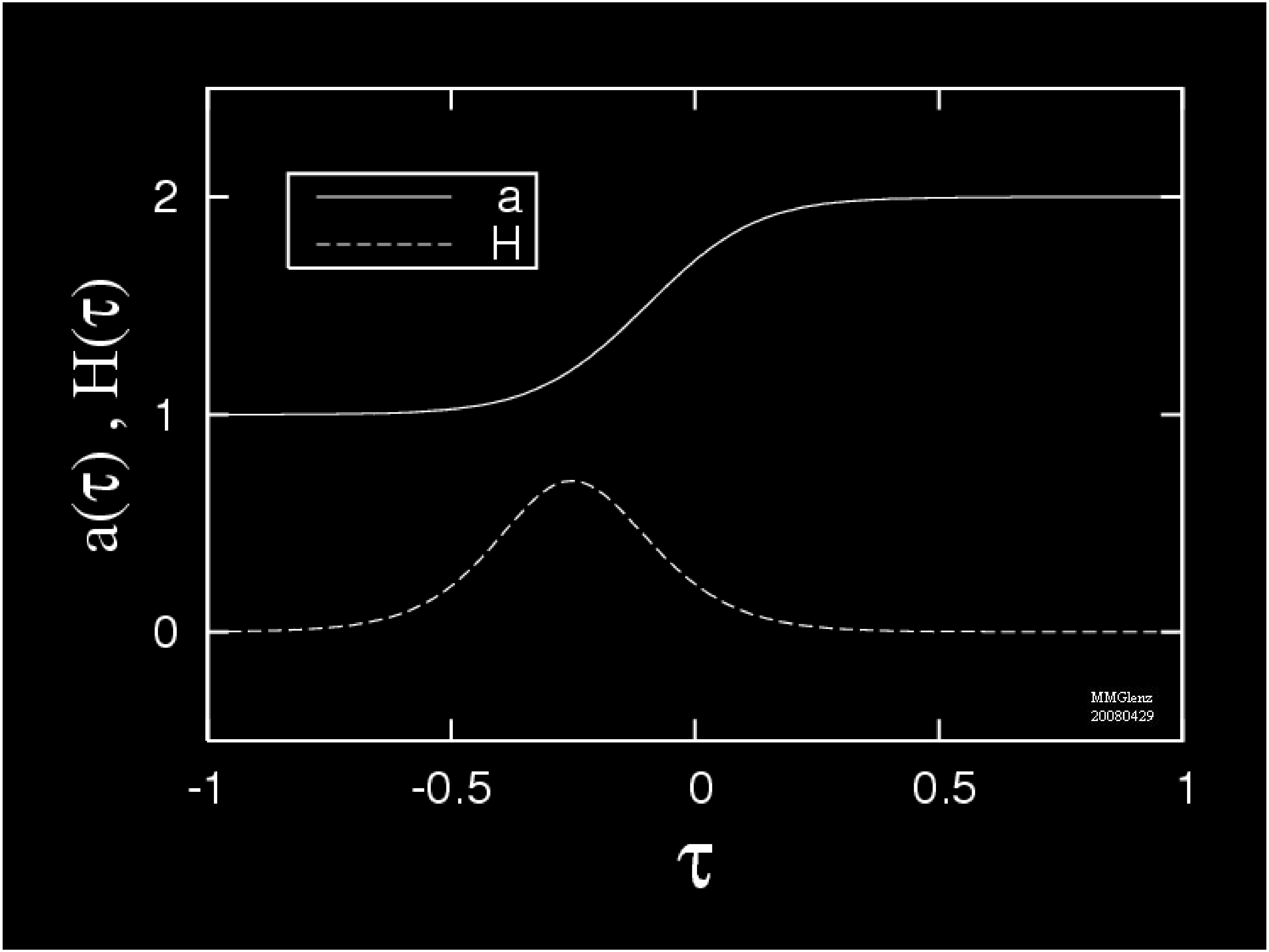

a
H
a(τ) , H(τ)
2
1
0
-1
-0.5
0
0.5
1
τ
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EARLY- AND LATE-TIME VACUUMS ARE RELATED BY A BUGOLIUBOV TRANSFORMATION.

$$a_{\vec{k}} = \alpha_k A_{\vec{k}} + \beta_k^* A^\dagger_{-\vec{k}}$$

$$\left\langle N_{\vec{k}} \right\rangle_{t\longrightarrow\infty} = \langle 0 | \, a^\dagger_{\vec{k}} a_{\vec{k}} \, | 0 \rangle = \left| \beta_k \right|^2$$

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DEFINITIONS:

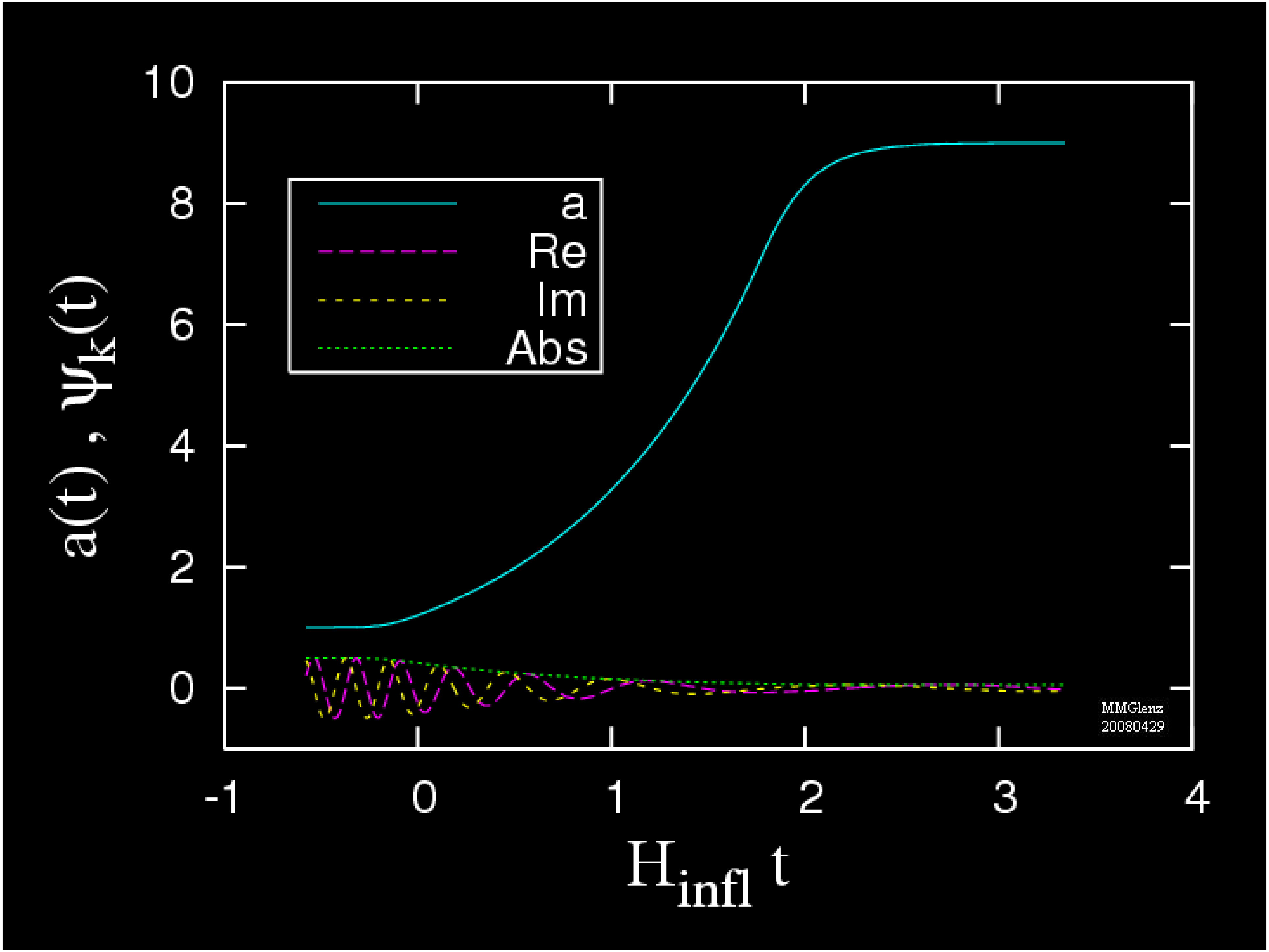
$$H = \frac{da/dt}{a} \qquad q_2 = \frac{k}{a_{final}\, H_{inflation}}$$

$$m_H = \frac{m}{H_{inflation}} \qquad \text{e-folds} = \int H\, dt$$

WE WANT TO KNOW THE LATE-TIME PARTICLE PRODUCTION

$$\phi(\vec{x}, t) = \phi(t) + \delta\phi(\vec{x}, t)$$

$$\delta\phi = (v)^{-1/2} \sum_{\vec{k}} [a_{\vec{k}} \psi_k(t) e^{i\vec{k}\cdot\vec{x}} + H.c.]$$


a
Re
Im
Abs
10
8
6
4
2
0
-1
0
1
2
3
4
$a(t)\ ,\ \psi_k(t)$
$H_{infl}\ t$
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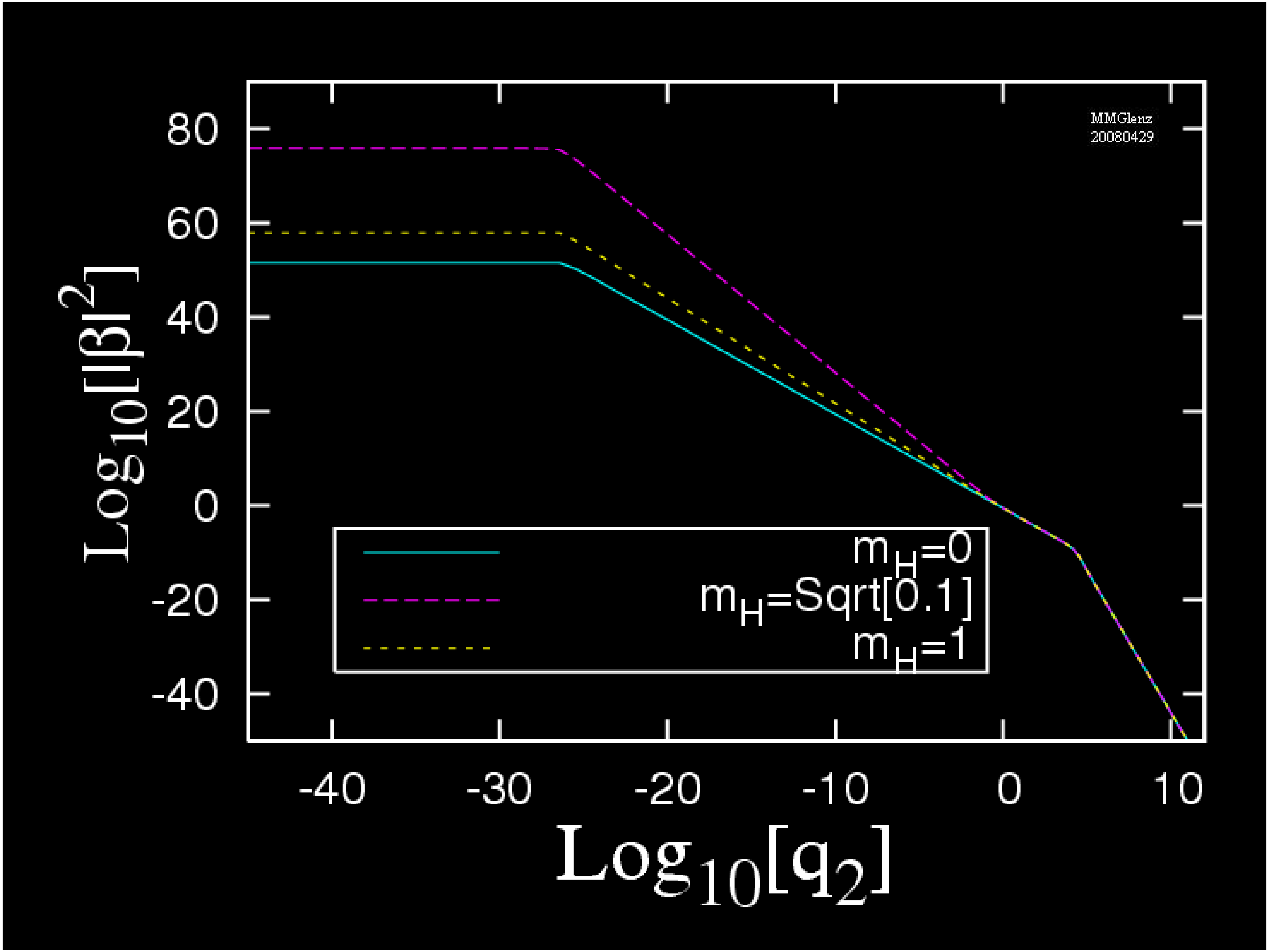
EVOLUTION EQUATION

$$\partial_t{}^2\delta\phi + 3H\partial_t\delta\phi - a^{-2}(t)\sum_{i=1}^{3}\partial_i{}^2\delta\phi + m(\phi^{(0)})^2\delta\phi = 0$$

$$m(\phi^{(0)})^2 = \frac{d^2V}{d(\phi^{(0)})^2}$$



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80
60
40
20
0
-20
-40
-40
-30
-20
-10
0
10
$Log_{10}[|\beta|^2]$
$Log_{10}[q_2]$
$m_H=0$
$m_H=Sqrt[0.1]$
$m_H=1$

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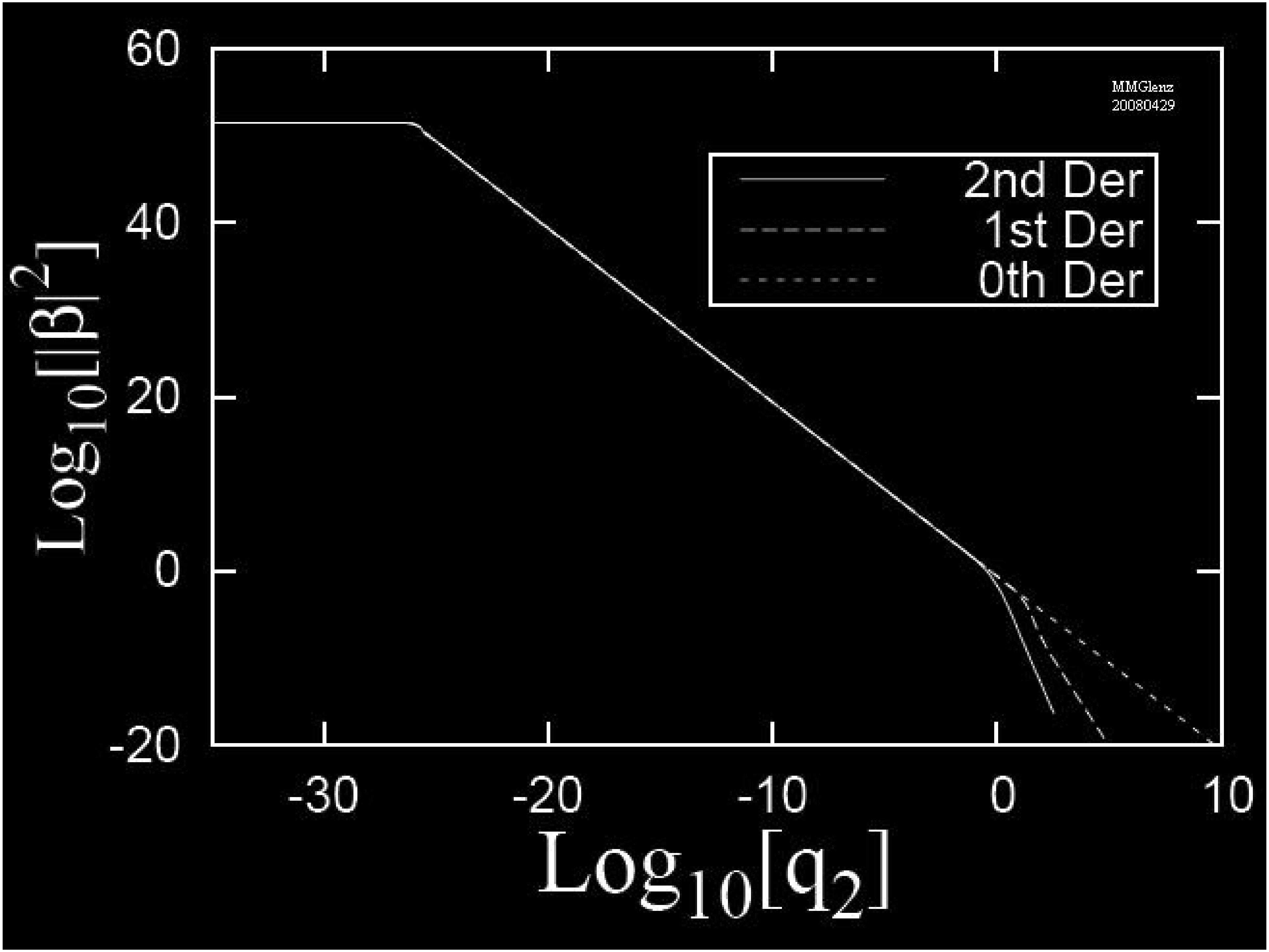
$$n_s = 4 - \sqrt{9 - 4m_H^2}$$

δ_H: $V = \frac{1}{2}m^2\phi^2$	$H = 10^{12}\text{GeV}$	$H = 10^{14}\text{GeV}$	$H = 10^{16}\text{GeV}$
$m_H = \frac{1}{10000}$	2.263×10^{-4}	2.263×10^{-2}	2.263×10^{0}
$m_H = \frac{1}{100}$	2.263×10^{-6}	2.263×10^{-4}	2.263×10^{-2}
$m_H = \frac{1}{10}$	2.258×10^{-7}	2.258×10^{-5}	2.258×10^{-3}
$m_H = \frac{1}{4}$	8.917×10^{-8}	8.917×10^{-6}	8.917×10^{-4}
$m_H = 1$	1.903×10^{-8}	1.903×10^{-6}	1.903×10^{-4}



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2nd Der
1st Der
0th Der
60
40
20
0
-20
-30
-20
-10
0
10
$Log_{10}[|\beta|^2]$
$Log_{10}[q_2]$

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$$\langle E \rangle \simeq \frac{H_{infl}^4 e^{2Y}}{16\pi^2}$$

$$Y \sim \ln\left(\frac{a_{2f}}{a_{2f} - a_{1f}}\right)$$

$$\langle\, |\, \delta\phi^2\, |\, \rangle = \frac{1}{2(a_{2f}L)^3} \sum_k \left[\frac{1 + 2|\beta_k|^2}{\sqrt{(k/a_{2f})^2 + m^2}} \right]$$

$$Z \equiv \frac{q_2 |\beta_{q_2}|^2 H_{infl}^2}{2\pi^2 \sqrt{1 + \frac{m_H^{\,2}}{q_2^{\,2}}}}$$

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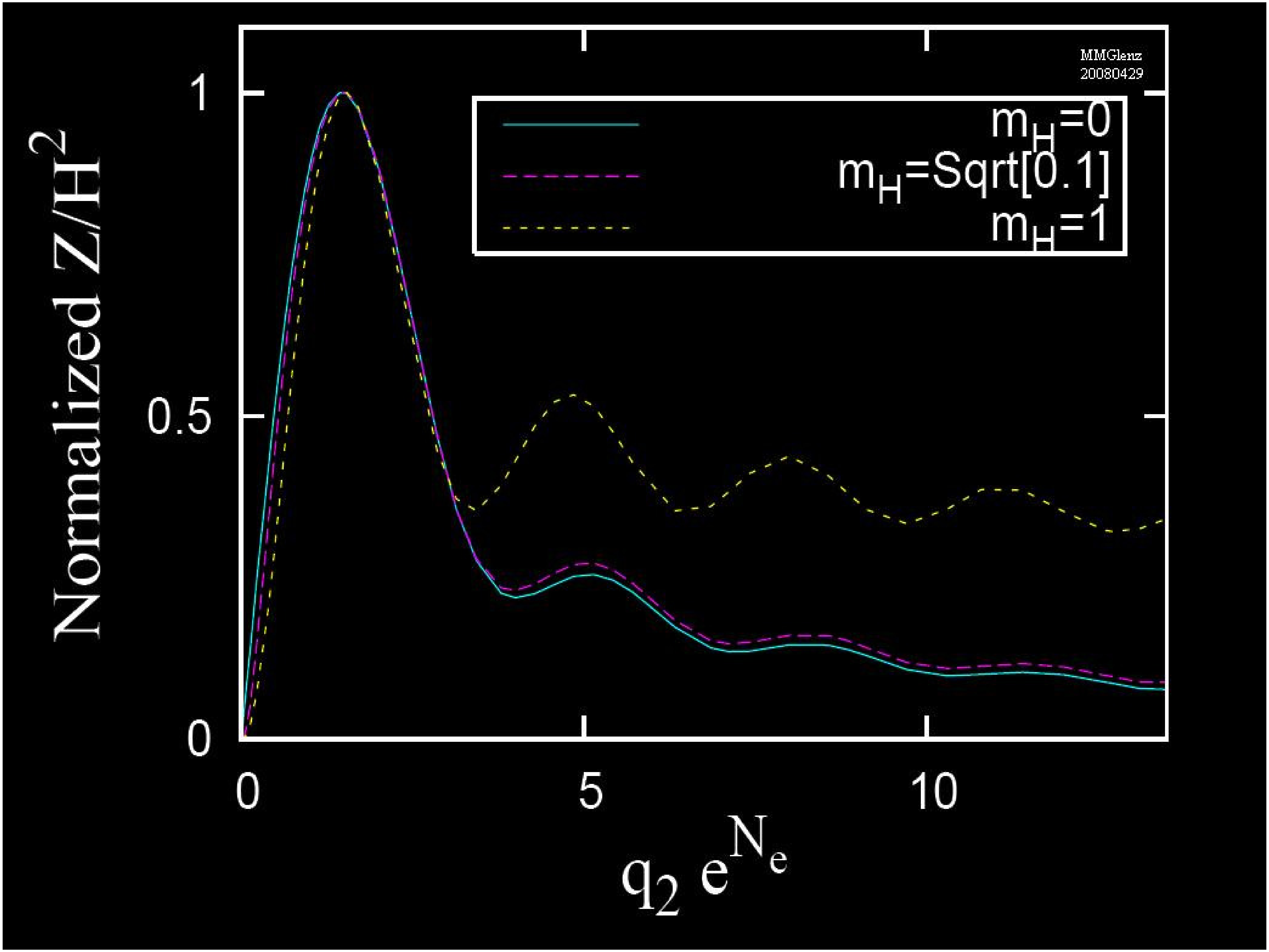
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Normalized Z/H^2
m_H=0
m_H=Sqrt[0.1]
m_H=1
0
0.5
1
0
5
10
q_2 e^N_e

Thank You

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