Dark Energy at Future Colliders: Testing the True Nature of Dark Energy in Black Hole Evaporations

Jörg Jäckel

Bonn, September 2005

Michael Doran

astro-ph/0501437

DESY

0. Overview

- 1. Introduction
- 2. Black Holes in LED
- 3. Large Extra Dimensions
- 4. A Few Details
- 5. Conclusions and Outlook

1. Introduction

Λ or ϕ ?

Cosmological Observations

- If, $w \neq -1$ we will eventually detect it!

- But: Suppose w continues to converge towards -1?

➡ It is impossible to exclude Quintessence with cosmological observations

Cosmological Observations

- Why?

  It is possible to „fit" any evolution history of the scale factor with a suitable potential!

Direct Detection Of Quintessence

- Next to impossible!

  Interactions with ordinary matter are of at most gravitational strength!

- A possible exception: Some theories of varying α suggest violations of the equivalence priciple (fifth force) which should be detectable in the near future!

2. Black Holes – a way out

Difference between Λ and ϕ

- Quintessence ϕ is a dynamical field
- It has particle like excitations (in contrast to Λ)

➡ ϕ is a „true" degree of freedom

Idea: Count the total # of d.o.f.

Thermal Democracy: Counting d.o.f.

- An ideal black body radiates into all thermalized degrees of freedom with equal intensity!

➡ radiated energy/time ~ # d.o.f.

- But! Small interaction strength prevents Quintessence from reaching thermal equilibrium!

Black holes

- Black holes are a black body radiator with Hawking temperature

$$T_H = \frac{n+1}{4\pi r_H} = \frac{n+1}{4\sqrt{\pi}} M_\star \sqrt[n+1]{\left(\frac{M_\star}{M_{BH}}\right)\left(\frac{n+2}{8\Gamma\left(\frac{n+3}{2}\right)}\right)}.$$

- „Thermal equilibrium" for all particles (interacting with gravity)
- All particles with M<<T are emitted with `equal´ probability!

$$\Rightarrow \quad \#\ of\ d.o.f. \sim \frac{E}{E_x}$$

This can Exclude Quintessence!!

- If we can account for all measured d.o.f. we have excluded Quintessence!

Astrophysical Black Holes

- But: Typical astophysical BH have

$$T \sim 62 \frac{\mathrm{M}_{\odot}}{M} \mathrm{nK}$$

- Too cold + too far away

➡ radiation not detectable

We need small black holes?!

- Yes, small, but not too small

$$0.1\,\mathrm{eV} \lesssim T \lesssim 1\mathrm{TeV}$$

$$1t = 10^{14} M_\mathrm{P} \lesssim M \lesssim 10^{27} M_\mathrm{P} = 10^{13} t$$

- Upper limit (in T) ensures that we have sufficient knowledge of „standard model particles“
- Lower limit: enough radiation

eBay item 4533803686 (Ends Mar-11-05 17:45:48 PST) - Black Holes - Mozilla

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop file:///C:/temp/bh3.htm#stockphoto Search Print

Home Bookmarks The Mozilla Organiza... Latest Builds

home | pay | register | register | sign in | sign in | services | site map

Start new search Start new search Search

Advanced Search

Buy | Sell | My eBay | Community | Help

Powered By IBM Powered By IBM

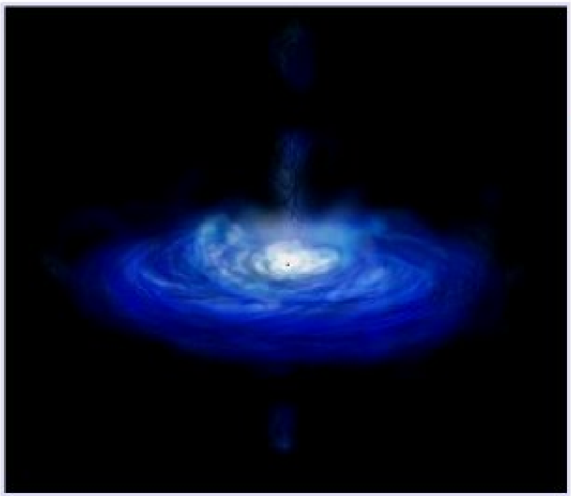
Back to list of items Listed in category: Books > Nonfiction Books

Black Hole

Item number: 4533803686

Seller of this item? Sign in for your status

Email to a friend | **Watch this item** in My eBay



Stock Photos

Larger Picture

Starting bid: **10^32 GeV**

Place Bid >

Buy It Now price: **10^40 GeV**

Buy It Now >

Time left: **Until decay**
time depends on mass, ends somewhere in the future

Start time: The Collsision

History: 0 bids

Item location: somewhere in the local group
The Universe

Ships to: No shipping available

Shipping costs: has to be picked up by customer

Shipping, payment details and return policy

Seller information

Little Sucker (0)

Feedback Score: 0
Positive Feedback: No Feedback
Member since briefly after the The Big Bang in The Universe

Read feedback comments

Add to Favorite Sellers

Ask seller a question

View seller's other items

PayPal Buyer Protection NEW!
Free Coverage now up to $1,000. See eligibility.

Description

Black Holes

Start C... t... M... bl... D... C... C... b... e... J... G... 15:11

3. Large Extra Dimensions

Large Extra Dimensions

- Luckily: In theories with LED the Planck mass is smaller
- $$S = \int d^{4+n}x\sqrt{g}[M_\star^{2+n}R + \ldots]$$
  $$\approx V_{ED}\int d^4x\sqrt{g_4}[M_\star^{2+n}R_4 + \ldots]$$

➡ $$M_{\mathrm{P}}^2 \sim V_{ED}M_\star^n \sim l^{2+n}M_\star^n$$

Large Extra Dimensions

- E.g. $l = 200\mu m \sim \frac{1000}{\mathrm{eV}}$ $\quad n = 2$

$$10^{54}\mathrm{eV}^2 \sim M_{\mathrm{P}}^2 \sim l^n M_\star^{2+n}$$

$$\Rightarrow \quad \boxed{M_\star \sim 1\mathrm{TeV}}$$

For n>5 this value is experimentally allowed

Black Holes in Large Extra Dimensions

- BH with desired T may be produced at Colliders (LHC), e.g.

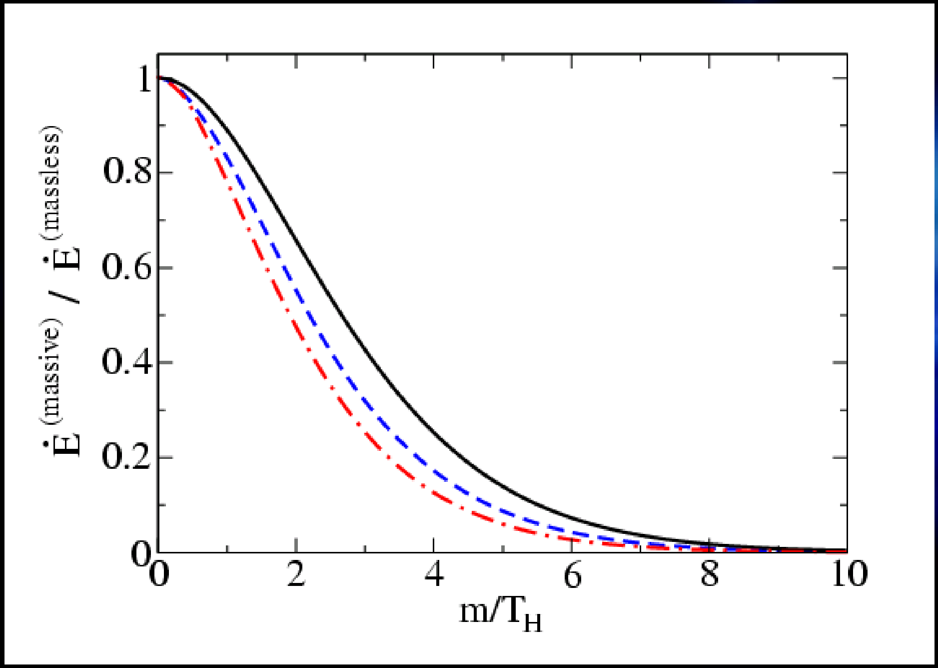
$$M = 10\text{TeV}, \quad M_\star = 1\text{TeV}$$

➡ $$T \approx 55 - 580\text{GeV}$$

4. A Few Details

Not all particles are massless :-)

- Heavy particles ($M \gtrsim T$) are supressed by the Boltzmann factor



➡ We do not need to know all particles with M>>T, only „light" particles contribute

Black holes are... grey

- BH are not ideal black bodies!

  (gravitational) potential well,

  ➡ some reflection back into the BH
- So called greybody factors account for this.
- This leads to different efficiencies for different particle types (scalars, fermions, gauge bosons)
- This may be used to determine the # of extra dimensions!

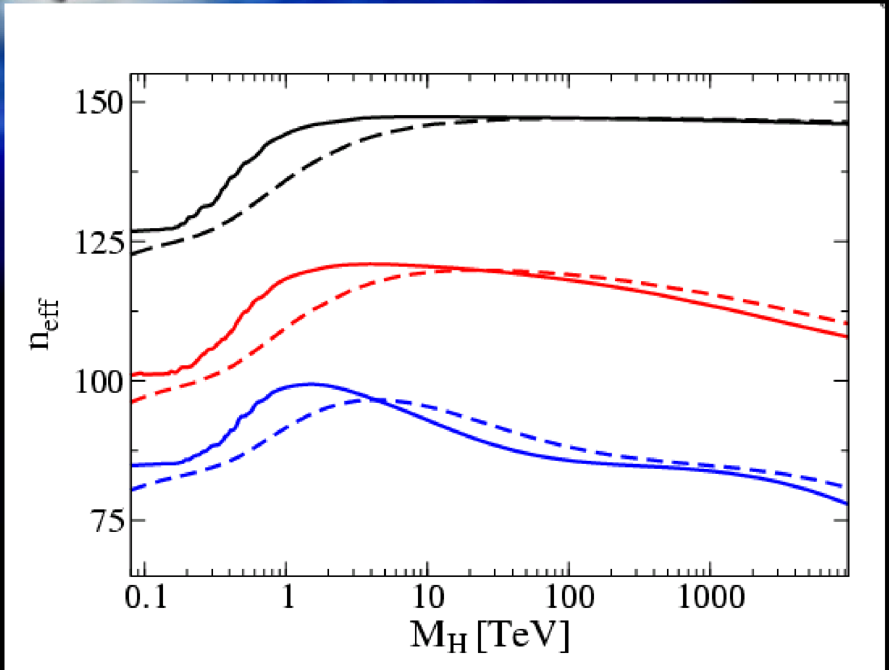
What accuracy do we need?

- Quintessence adds one d.o.f.

➡ we need an accuracy

$$acc. \sim \frac{1}{\#\ d.o.f.\ \ total} \sim 0.5\%$$

Standard model
has roughly
100 d.o.f.



Bonus Level: Neutrinos

- Light Dirac neutrinos have four (light) d.o.f.
- See-sawed Majorana neutrinos 2 d.o.f.

We can test for the nature of neutrinos

Neglected Stuff: Phases of Black Hole Decay

- Balding Phase: Assymetry and other ´hair` (quantum numbers) are lost
- Spin-Down phase: angular momentum is lost
- Schwarzschild phase: This is what we discussed
- Planck phase: Quantum gravity regime

5. Conclusions

Conclusions

- Cosmological observations have a hard time distiguishing between Λ and ϕ
- Λ and ϕ can be distinguished by counting d.o.f.
- Black holes are provide black bodies with Quintessence in thermal eq.
- Measure the energy deposited into known particles ➡ total # of d.o.f.
- If $M_P \sim 1$TeV measurement may be feasible

Outlook

- Calculation of massive grey body factors for particles with spin
- Grey body factors for gravitons???