

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

**visible cosmic network of deep sky filaments
("Murray mesh") as redshifted hard gamma
radiation from macroscopic cosmic F- and
D-strings from epoch just after inflation
(Copeland, Myers, Polchinski 2004.05.25): Murray
2004.06.19 rmforall**

Source: <http://sci.tech-archive.net/Archive/sci.physics/2004-06/6092.html>

From: Rich Murray (rmforall_at_att.net)

Date: 06/19/04

Date: Sat, 19 Jun 2004 02:52:53 -0600

<http://groups.yahoo.com/group/AstroDeep/7>

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (Copeland, Myers, Polchinski 2004.05.25):
Murray 2004.06.19 rmforall

Rich Murray, MA Room For All rmforall@comcast.net
1943 Otowi Road, Santa Fe, New Mexico 87505 USA 505-501-2298

2004 June 19

On August 30 2001, I became intrigued with easily visible, equally easily dismissable networks of faint, thin, crooked, connected, continuous threads, discernable with patient scrutiny of almost all deep sky images at visible and infrared ranges.

<http://groups.yahoo.com/group/AstroDeep/1>

<http://photos.groups.yahoo.com/group/astrodeep/1st?.dir=/&.view=t>

deep sky background filaments: images and interpretation:

Murray 2002.01.19 rmforall

Click on the thumbnail photos to get the photos, and click on those in turn to get full screen photos.

Artifacts? Or?— immense filaments of H, He, and dark matter, lit by intense UV from the earliest very massive stars, "...during the first 10E8 years of the history of the universe at redshifts between 50 and 10..."

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

Prof. Richard B. Larson, Sci. Am. Dec 2001, and
<http://www.astro.yale.edu/larson/papers/Noordwijk99.pdf>
[7 pages]. This very early intense UV is now redshifted
into the visible and IR bands, and may supply about half of
the current cosmic IR background. The filaments are
generally as thin as 1 pixel.

Photo #2: [deeptt1k.jpg](#):

One pixel = .258 arc-sec, about .25 mm on my 15" monitor.
In MGI PhotoSuite 4.0, I can zoom in to 1600 %, at which point
each pixel is about 4 mm on my 15" monitor.

This is a 20KB cut from the center of the
673 KB original, Photo #1: [deeptt1.jpg](#):
1024X1024 pixels, a random sample, the first of three,
a little to the lower left of center of the 1.15X1.15 degree field,
16000X16000 pixels, 750.3 Mb 24-bit color TIFF,
the highest available resolution,
http://www.noao.edu/image_gallery/html/im0637.html
National Optical Astronomy Observatory Deep Wide-Field Survey.

I was captivated by the article with images,
Sky & Telescope Sept 2001
p. 42-45 by David Tytell. In this article,
image #7 has twice the resolution of the other six closeups,
2.6X2.6 arc-min in a 13.1X13.1 cm square. I noticed that by looking
in relaxed way into the dark background for a few minutes, I could
start to discern a network of dark, thin, tangled filaments,
on Aug 30, 2001. Intrigued, I started downloading and
studying images from the NOAO website.

Photo #3: [deeptt1.jpg](#):

Using a \$ 50 program, MGI PhotoSuite 4.0, available from
<http://www.mgisoft.com>, 505-764-7291, on Dec 12, I used the
Touchup Filters function to change Gamma from 1.00 to 6.00,
revealing a tangle of red and green thin filaments, and a few
red and green spots in the formerly dark background.

I am assuming that the original photo uses only light in the visible
range, with no data from infrared bands added in-- I will be
grateful for clarification about this important point. What exactly
are the measured wavelengths, how are they coded as the
colors in the image, what is the angular size of a pixel, and how
many photons are recorded as the brightness levels of a pixel?

Photo #4: [deeptt1m.jpg](#):

Brightness was increased from 0 to +30.

Photo #5: [deeptt1n.jpg](#):

Invert reversed both colors and black and white,
and brightness was increased from 0 to +75.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

Zoom In from about 100 to 200 [The maximum zoom is 1600, and then the pixels are about 4 mm wide on my monitor]. This makes the tangle of dark and some light green filaments convincingly obvious, along with striking bright pink and green spots.

Photo #6: [deeptt1o.jpg](#):

Invert, revealing a stronger image of the filaments seen in Photo # 3.

Photo #7: [deeptt1ka.jpg](#):

This is a collage, zoomed in, from Photos #2, 3, 5, 6.

PhotoSuite saves collages as pzp files, which can also be saved as tiff and jpg versions. Yahoo Photos will accept only the jpg versions, which are noticeably more grainy than the pzp and tiff versions. Much more can be seen when you download 5 to 10 MB tiff files and image process them yourself. Incidentally, I would love to be given a CD of any version of Adobe Photoshop.

Photos #8 to 23 present photo pairs, along the same pattern of image modification, zooming in deeper and deeper. About two decades ago I noticed that when the same photo is set up side by side, and viewed with slightly crossed eyes to make a third composite image in between, that image is created by the brain's visual system as an excellent 3D image. In fact, you can visit a TV store, where a lot of sets are all on the same channel at once, and find two sets the same size, side by side, and watch the composite image in moving 3D. If you settle your gaze gently for a few minutes into the composite image, the innate image processing facility of the brain's visual system will develop and deepen the 3D appreciation in remarkable and beautiful ways.

[end of extract from 2002.01.19 post]

Inspecting images in magazines and on the Net since then for two years, I have found it easier and easier to verify the original discovery.

Use of an image processor to magnify deep sky images shows that the filaments are always behind foreground objects, such as galaxies.

They usually are as thin as a single or a few pixels, yet each thread maintains a fairly limited range of colors and intensities.

The threads characteristically form a mesh, crooked, connected, and continuous, with few isolated spots, segments, or circles— rather like a loosely knit wool sweater.

The mesh seems much the same at all magnifications, indicative of a fractile, scale-invariant structure.

The actual size of the sources may, of course, be much smaller than the angular resolution available as a pixel in recent deep sky images.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

Highly intense gamma radiation would be able to some extent to escape the local environment of the sources and travel undeflected until eventual detection.

Murray mesh, if factual and not artifactual, must be a complex 3D structure, probably fractile, across a range of redshifts, during which the source outputs must be varying complexly in intensity and frequency, as well as in polarization, orientation to line of sight, and rate of fluctuation.

A long thread will display an evolution of successive phases along its crooked length if it happens to largely line up with our line of sight.

The recorded signals will be subject to complex dispersions and absorptions by their hot, dense local environment as well as the line of sight absorptions from successive epoches along the line of sight.

I haven't discerned signs of gravitational magnification of the mesh by foreground galaxies and clusters, which indicates that the sources are too distant to be "in focus".

The downshifting from hard gamma, perhaps 10^{22} Hz, to infrared, about 10^{13} Hz, would be a redshift factor of a billion.

<http://www.damtp.cam.ac.uk/user/gr/>
Cambridge Relativity & Gravitation Research Home Page
http://www.damtp.cam.ac.uk/user/gr/public/bb_history.html
Brief History of the Universe

This chart indicates that, from:

Grand unification transition: $G \rightarrow H \rightarrow SU(3) \times SU(2) \times U(1)$
Inflation, baryogenesis, monopoles, cosmic strings, etc?
time = 10^{-35} sec
Temperature = 10^{15} Gev = 10^{24} electron volt

to Santa Fe, New Mexico:

time = 13.7 billion years = 430 million billion seconds = 4.3×10^{17} seconds
[1 year = 3.15×10^6 seconds]
Temperature = 3 degrees K = 1 milli electron volt, 10^{27} times less.

So, there's plenty of room to redshift some pretty hard gamma rays.

Speculations in recent theoretical cosmology provide a class of candidate sources.

"In principle, fundamental strings could have been produced in the early universe and then grown to macroscopic size with the expansion of the universe."

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

"After their formation at the end of inflation, string networks decay by the combined processes of intercommutation, which breaks longer strings into smaller loops, and gravitational radiation."

".....Superconducting strings may act as sources for vortons [51], loops of cosmic string with charge and current stabilized by the angular momentum of the charge carriers.

In this case they would be subject to bounds on their allowed tension, with $10^{-28} < \sim G\mu < \sim 10^{-10}$ being claimed to be a cosmologically unacceptable range of values [52].

If the energy scale associated with superconducting strings were close to the electroweak scale, then the vortons could become serious candidates for cold dark matter."

"If the string couples strongly to Standard Model fields then instead of primarily producing gravitational radiation the string network may decay through the production of high energy cosmic rays, photons and neutrinos from string cusps [55]."

http://arxiv.org/PS_cache/hep-th/pdf/0312/0312067.pdf

arXiv:hep-th/0312067 v5 25 May 2004

Preprint typeset in JHEP style – HYPER VERSION

Cosmic F- and D-strings

Edmund J. Copeland
Department of Physics and Astronomy
University of Sussex
Brighton, BN1 9QJ, UK
E-mail: e.j.copeland@sussex.ac.uk

Robert C. Myers
Perimeter Institute for Theoretical Physics
Waterloo, Ontario N2J 2W9 Canada
and
Department of Physics
University of Waterloo
Waterloo, Ontario N2L 3G1 Canada
E-mail: rmyers@perimeterinstitute.ca

Joseph Polchinski
Kavli Institute for Theoretical Physics
Santa Barbara, CA
93106-4030, USA
E-mail: joep@kitp.ucsb.edu

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

Abstract: Macroscopic fundamental and Dirichlet strings have several potential instabilities: breakage, tachyon decays, and confinement by axion domain walls. We investigate the conditions under which metastable strings can exist, and we find that such strings are present in many models. There are various possibilities, the most notable being a network of (p, q) strings. Cosmic strings give a potentially large window into string physics.

Contents

1. Introduction	1
2. Stability Conditions	3
2.1 Breakage	3
2.1.1 Breakage on an M4-filling brane	3
2.1.2 Breakage on a 'baryon'	4
2.2 Axion domain walls	6
2.3 Two puzzles	7
2.3.1 The first puzzle	7
2.3.2 The second puzzle	8
3. The KKLMMT model	9
3.1 Generalities	9
3.2 Scenarios	11
3.2.1 No branes in the throat	11
3.2.2 Stabilizing D3-branes in the throat	13
3.2.3 Standard model branes in the throat	14
4. Large dimension models	15
5. Observational consequences	16
5.1 String properties	16
5.1.1 Tension	16
5.1.2 Superconductivity	17
5.1.3 Intercommutation	17
5.1.4 Network properties	18
5.2 Observational bounds	19
6. Conclusions	21

1. Introduction

Before the 'second superstring revolution' there appeared to be a clear distinction between fundamental strings and cosmic strings.

Fundamental strings were believed to have tensions μ close to the Planck scale. In perturbative heterotic string theory,

page – 1 –

for example, $G\mu = GUT/16\pi \gtrsim 10^{-3}$, whereas the isotropy of the cosmic microwave background implied (even before COBE) that any string of cosmic size must have $G\mu < \sim 10^{-5}$ [1].

Thus any cosmic strings would have had to arise in the low energy effective field theory, as magnetic or electric flux tubes.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

In principle, fundamental strings could have been produced in the early universe and then grown to macroscopic size with the expansion of the universe.

Inflation provides a simple explanation for the absence of cosmic fundamental strings of such high tension.

However, even aside from inflation it was noted in ref. [2] that there are effects that would prevent the appearance of cosmic fundamental strings.

Macroscopic type I strings break up on a stringy time scale into short open strings, and so would never form.

Macroscopic heterotic strings always appear as boundaries of axion domain walls, whose tension would force the strings to collapse rather than grow to cosmic scales [3].

At the time of ref. [2] no instability of long type II strings was known, but it is now clear that NS5-brane instantons [4] (in combination with supersymmetry breaking to lift the zero modes) will produce an axion potential and so lead to domain walls.

Today the situation in string theory is much richer.

First, many new onedimensional objects are known: in addition to the fundamental F-strings, there are D-strings, as well as higher dimensional D-, NS-, M-branes that are partially wrapped on compact cycles so that only one noncompact dimension remains.

Second, the possibility of large compact dimensions [5] and large warp factors [6] allows much lower tensions for these strings.

Third, the various string-string and string-field dualities relate these objects to each other, and to the field-theoretic flux tubes, so that they are actually the same object as it appears in different parts of parameter space.

Thus it is important to revisit this subject, and ask whether some of these strings may be cosmologically interesting.

Indeed, it has been argued by Jones, Sarangi, and Tye and by Stoica and Tye [7] that D-brane-antibrane inflation [8] leads to the copious production of lowerdimensional D-branes that are one-dimensional in the noncompact directions.

This is a special case of the production of strings in hybrid inflation [9].

Refs. [7] also make the important observation that zero-dimensional defects (monopoles) and two-dimensional defects (domain walls) are not produced; either of these would have led to severe difficulties.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

It is necessary then to investigate the stability of possible cosmic strings against the processes noted above.

A naive extrapolation of the results of ref. [2] would suggest that all BPS strings are confined by domain walls, and that all non-BPS strings are unstable to breakage or tachyon decay.

We will find that the situation is more interesting, and that stable strings exist in certain classes of models but not in others.

In §2 we investigate this subject, and identify conditions under which long strings can be at least metastable.

Our focus is on type I/II theories, though the same

page – 2 –

principles will hold in heterotic and M theory compactifications.

In §3 we apply our conditions in the string theory inflation model of Kachru, Kallosh, Linde, Maldacena, McAllister, and Trivedi (KKLMT) [10], which is based on the stabilization of all moduli in the warped IIB framework of ref. [11].

We find that the nature of the cosmic strings in this model depends on precisely how the Standard Model fields and the moduli stabilization are introduced.

We identify three possibilities:

- (a) no strings;
- (b) D1-branes only (or fundamental strings only);
- (c) (p, q) strings – bound states of p fundamental strings and q D-strings for relatively prime (p, q) – with an upper bound on p.

In §4 we briefly discuss large compact dimension models without large warp factors, and find a similar range of possibilities.

In §5 we discuss the observational signatures of these cosmic strings.

Although the various bounds currently are all in the area of $G\mu < \sim 10^{-6}$, there are future observations that will reach many orders of magnitude further in $G\mu$.

With (p, q) strings there are more complicated string networks than when only one type of string is present.

This may enhance the signatures for these strings, and possibly place strong constraints on models of these types.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

While we were completing this work we learned of papers on related subjects by Dvali, Kallosh and Van Proeyen [12] and by Dvali and Vilenkin [13]

.....

..... 5.1.4 Network properties

After their formation at the end of inflation, string networks decay by the combined processes of intercommutation, which breaks longer strings into smaller loops, [8]

[8 There has been extensive study of two-dimensional supersymmetric networks formed in this way; see for example ref. [41].]

page - 18 -

and gravitational radiation.

For gauge theory strings there is also the decay process due to the fields themselves, and there is a debate as to which of the decay processes dominate (gravitational versus Higgs) [43, 44].

Assuming gravitational radiation dominates, then if the decay proceeds at the maximum rate consistent with causality, the distribution of strings will scale with the horizon volume.

This scaling behavior leads to an energy density that goes as t^{-2} , so that $w = 1/3$ in the radiation-dominated era and $w = 0$ in the matter-dominated era.

That is, in each era the energy density in strings is a fixed fraction of the total energy density.

Simulations indicate that networks composed of a single kind of string do scale, with

$\rho_{\text{string}}/\rho_{\text{rad}} \sim 400 G\mu$ in the radiation dominated era and
 $\rho_{\text{string}}/\rho_{\text{mat}} \sim 60 G\mu$ in the matter dominated era.

These values are for recombination probability $P = 1$ and increase as P decreases [45].

When there are several kinds of string, with trilinear vertices, then there is the possibility that the network evolves to a three-dimensional structure which freezes in a local minimum of the potential energy and then just grows with the expansion of the universe.

In this case the energy density would evolve as $a(t)^{-2}$, or $w = -1/3$.

Whether the network freezes or scales is a complicated dynamical problem.

Such networks arise in field theory when a symmetry group G breaks to a discrete subgroup K .

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

When K is non-Abelian, intercommutation cannot occur, rather the network evolves as in figure 5.

Simulations of $K = Z_3$ (with string vertices provided by monopoles) [46] and $K = S_3$ [47, 48] indicate that these systems scale rather than freeze, but with some enhanced density of strings.

Simulations of $K = S_8$ [47] show an energy density that grows relative to the scaling solution and appears to indicate freezing behavior.

This is consistent with the fact that the larger group allows networks of greater topological complexity, but it could also be a reflection that the simulations in [47] have not yet managed to reach the scaling regime.

It is worth investigating this issue further.

To determine whether networks of (p, q) strings scale or freeze will ultimately require simulations.

We conjecture that they scale, in that their topological complexity appears to be roughly that of the S_3 networks.

If g_s is close to one, only the four lowlying strings with $|p|, |q| = 1$ are likely to be heavily populated.

For any crossing between two lowlying strings, one of the two processes in figure 5 will again involve only lowlying strings, and for most angles of crossing this process will be energetically favored.

Another argument for scaling behavior is to consider the limit $g_s \ll 1$, where the D-strings are much heavier than the F-strings.

The D-strings should then evolve largely independently of the F-strings, and so scale like a single-string network; after the D-strings decay to the scaling distribution on a given length scale, the F-strings in turn evolve like a single-string network.

5.2 Observational bounds

If a string network freezes into a $w = -1/3$ state, it quickly comes to dominate

page – 19 –

the energy density of the universe unless the initial energy scale is much lower than those considered above: it must be of order the weak scale or less.

Thus if (p, q) string networks freeze, models with (p, q) strings are excluded with the parameters considered here.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

Again, our conjecture is that they do not freeze.

Assuming a scaling distribution of cosmic strings, the current upper bound on $G\mu$ comes from the power spectrum of the CMB, based on numerical evolution of the Nambu-Goto equations: $G\mu < \sim 0.7 \times 10^{-6}$ [49] (see also ref. [50]).

The tensions given in section 5.1.1 for the various models are below this bound.

On the other hand numerical evolution of the underlying Abelian-Higgs field theory has led Vincent et al to argue that the bound is closer to $G\mu \sim 10^{-8}$ [43] (however see also [44]).

Superconducting strings may act as sources for vortons [51], loops of cosmic string with charge and current stabilized by the angular momentum of the charge carriers.

In this case they would be subject to bounds on their allowed tension, with $10^{-28} < \sim G\mu < \sim 10^{-10}$ being claimed to be a cosmologically unacceptable range of values [52].

If the energy scale associated with superconducting strings were close to the electroweak scale, then the vortons could become serious candidates for cold dark matter.

In the context of the KKLMT model, this would correspond to having inflation in the throat occurring at or around the electroweak scale.

Cosmic strings produce large quantities of gravitational waves, because they are relativistic and inhomogeneous.

Pulsar timing measurements then place an upper bound on $G\mu$ which is roughly comparable to that from the CMB, depending on uncertainties from network properties [53].

Remarkably, future measurements of non-gaussian emission of gravitational waves from cusps on strings will be sensitive to cosmic strings with values of $G\mu$ seven orders of magnitude below the current bound, covering the entire range of tensions discussed in section 5.1.1.

According to ref. [54], even LIGO 1 may be sensitive to a range around $G\mu \sim 10^{-10}$, while LIGO 2 will reach down to $G\mu \sim 10^{-11}$ and LISA to $G\mu \sim 10^{-13}$.

In addition [54], pulsar timing measurements may reach a sensitivity of $G\mu \sim 10^{-11}$.

Thus, gravitational waves provide a potentially large window into string physics, if we have a model in which strings are produced after inflation and are metastable.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

If the string couples strongly to Standard Model fields then instead of primarily producing gravitational radiation the string network may decay through the production of high energy cosmic rays, photons and neutrinos from string cusps [55].

These authors have calculated the predicted flux of high energy gamma rays, neutrinos and cosmic ray antiprotons and protons as a function of the scale of symmetry breaking at which the strings are produced, and argued that in order to reproduce the (possibly) observed distribution of particles above the GZK cut-off, they require $G\mu = 10^{-9}$.

Given the values we expect in the KKLMT model this remains in the interesting regime for cosmic strings arising out of string theory.

Note however refs. [56], which argue that the cosmic radiation from cusps is suppressed.

page – 20 –

6. Conclusions

We have found that both fundamental and Dirichlet strings might be observed as cosmic strings.

The issue is model-dependent – it depends on having brane inflation to produce the strings, and on having a scenario in which the strings are stable.

Nevertheless, this is a potentially large and rather direct window onto string theory.

Of course, if cosmic strings are discovered, the problem will be to distinguish fundamental objects from gauge theory solitons.

Indeed, this is not a completely sharp question, because these are dual descriptions of the same objects.

If one can infer that the strings have intercommutation probabilities less than unity, this is a strong indication that they are weakly coupled F-strings.

Discovery of a (p, q) spectrum of strings would be a promising signal for F- and D-strings.

Note however that these throats have a dual gauge description [23] and therefore such strings can also be obtained in gauge theory; the spectrum is actually a signal of an $SL(2, \mathbb{Z})$ duality and so might arise in other ways as well.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

If cosmic strings are found through the gravitational radiation from cusps, determining their tensions and intercommutation properties will require a spectrum of many events as well as precise simulations of the evolution of string networks.

Acknowledgments

We would like to thank Stephon Alexander, David Berenstein, Robert Brandenberger, Alessandra Buonanno, Thibault Damour, Gia Dvali, Jaume Gomis, Chris Herzog, Nick Jones, Shamit Kachru, Renata Kallosh, Tom Kibble, Andrei Linde, Eva Silverstein, Scott Thomas, Sandip Trivedi, Mark Trodden, Henry Tye, and Alex Vilenkin for useful discussions.

We also thank Jose Blanco-Pillado, Greg Moore, and Ken Olum for comments on the manuscript.

EJC and RCM would like to thank the organizers of the String Cosmology program at the Kavli Institute for Theoretical Physics for their invitation to participate in such a stimulating meeting.

The work of RCM at the Perimeter Institute is supported by funds from NSERC of Canada.

The work of JP is supported by National Science Foundation grants PHY99-07949 and PHY00-98395.

<http://groups.yahoo.com/group/AstroDeep/6>

background filament networks (Murray mesh) in deep sky photos-- noise artifacts or early cosmic structure? Boehringer: Murray 2004.06.15 rmforall

2004 June 15

Bob, thanks for your lucid and careful comments about the very reasonable interpretation that the faint background filaments noticeable in the background of many extremely deep space photos at very high red shifts are possibly just noise.

In response to your second post on the effects of raising gamma on making random noise more visible in photos, I want to point out that the "Murray mesh" threads are visible on deep sky astronomical photos with gamma at the usual value 1.00, as in the case of the recent Hubble images of Abell 1689. Why would random pixels become a mesh of thin, long, crooked, continuous threads?

With a low-cost program MGI PhotoSuite 4, it is easy to use my 1.4 GHz Pentium 4 system to switch from gamma .30 to 3.00 in steps of .10 gamma, and magnification from .25 to 4.00, examining the variously colored more prominent threads. They are quite persistent.

They look to me like a scale invariant, fractile mesh, as predicted by current models of the evolution of initial large scale structure into filament networks around voids.

If this is what we are viewing, then of course we are looking from inside a dense large-scale condensed region, within which our local cluster of

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

galaxies has evolved, and so it would be expected that we would see the same dense network of filaments in all directions at a redshift earlier than the condensation of stars and galaxies in our region, since it is improbable that we would be located near the boundary of our region. So, the question of whether "Murray mesh" is artifactual or factual is worth exploring.

The Touchup Filters also includes Invert, which reverses all the colors. Switching every second to Invert and back makes it easy to find delicate threads that are visible in both modes.

Would you create a completely random 2 MB image with pixels evenly shared among white, black, violet, blue, green, yellow, orange, red, and put it on a site where anyone can copy it and look for similar artifacts?

The striking 3D effect of looking with relaxed, slightly crossed eyes for a while at paired identical images, until a third image emerges between them, is my direct experience. I have successfully guided many others to also have it. It is quite striking to pick out two color postcards in a shop and see the third 3D image hanging in space between them. I surmise that some level of the brain's image processing is cued by the slight convergence of the eyes to carry out the 3D interpretation function, even though the images are identical.

I find that I see much more in astronomical photos this way, even though the 3D quality may be somewhat off-- for instance, craters may be confused with hills. I'm interested in whether you and others report success or not in actually trying it with a number of photos. When I rotate both images 90 degrees or 180 degrees, I get the same effect-- a definite and enjoyable enhanced perception of the third image, quite different from focusing both eyes on a single image.

I welcome civil debate on these images.
Anyone can post to AstroDeep@yahoogroups.com

I had to place low-resolution JPG images in the archive at my discussion group <http://groups.yahoo.com/group/AstroDeep/1>

However, the filaments are even more convincingly obvious in the original TIFF images, up to 100 MB of color coded data, especially if the gamma is shifted from 1.00 to 2.00 or 3.00.

They show up in images of different sky locations, with different wavelengths, various color codings, and from a variety of large telescopes. They are easy to see in color deep sky photos in popular astronomy magazines, especially when the gamma has been shifted to about 2.00 to render the black background more luminous.

Try it with selections from the recent Hubble photo of Abell 1689 at

<http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/01/image/>

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

<http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/01/image/f>

This 1.89 MB TIFF image at 1X or 2X clearly show myriad red and black filaments in what I interpret as a deep 3D mesh, which can be seen behind as well as between the translucent foreground galaxies. I haven't seen any signs of gravitational lensing, which might be because they are too far behind the lensing cluster to be "in focus".

The 3D effect with paired identical color photos is very striking for me-- I can do it with tourist picture postcards in a store. I'm interested in how many people can readily experience various versions of 3D perception this way.

In mutual service, Rich

From: "Rich Murray" <rmforall@att.net>
Subject: Hubble sees via Abell 1689 to 2 B ly 1.7.3
Date: Tuesday, January 07, 2003 5:01 PM

Hubble sees via Abell 1689 to 2 B ly 1.7.3

Hubble Sees Deep Universe Using Cosmic 'Zoom Lens'

Updated 2:32 PM ET January 7, 2003

By Deborah Zabarenko

SEATTLE (Reuters) – Using a cosmic "zoom lens" made up of cluster of a trillion stars, the Hubble Space Telescope looked back in time to see the universe just 2 billion years after the theoretical Big Bang, astronomers said on Tuesday.

Hubble's new Advanced Camera for Surveys looked straight through a massive galaxy cluster known as Abell 1689. The gravity of the cluster's trillion stars acts as a monster magnifying glass in space, warping and magnifying the light of galaxies far behind it.

Abell 1689 is 2.2 billion light-years away, and it acts as a 2 million-light-year-wide "zoom lens" in space, scientists said at a meeting of the American Astronomical Society meeting in Seattle.

A light-year is about 6 trillion miles, the distance light travels in a year.

The new image appears at first glance as hundreds of jewel-like bright objects -- distant galaxies -- against a black background, much like previous Hubble pictures.

On closer examination, there are faint arcs of red and blue, the light from even more remote galaxies smeared by the gravitational bending of

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

the light as it is magnified.

"We create a kind of pothole in the geometry of the universe," said Narciso Benitez of the Johns Hopkins University, referring to the warping known as gravitational lensing.

Some of these galaxies have been seen before, but the new picture reveals 10 times more arcs than would be seen by a telescope on the ground, and makes an image twice as sharp as previous images from the orbiting Hubble's earlier cameras.

Hubble scientists also showed a new image of the dusty disk around a nearby baby star where planets could lurk.

The 5 million-year-old star -- a true infant in cosmic terms -- lies 320 light-years away in the constellation Libra and appears to be part of a triple-star system.

Earlier Hubble images showed two rings separated by a dark lane in the star's disk, and this was interpreted as evidence of one or more planets around the star.

The new disk image gives a more complex picture, revealing a tight spiral structure with two arms, one of which appears to be associated with a nearby double star system.

In a color image, there is a black blob where the light from the star has been masked to highlight the disk.

"In the picture, we're seeing an interaction between the binary system and the disk," said Holland Ford, also of Johns Hopkins. "We're not seeing planets in this disk, but there is nothing that would preclude planets in this debris disk."

Hubble images and information are available at <http://hubblesite.org/news/2003/01>

<http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/01/image/>

From: "Louise and Bob" <coatsbob@yahoo.com>
To: "Rich Murray" <rmforall@comcast.net>
Subject: Re: a friendly introduction: Beohringer: Murray 2004.06.12
Date: Monday, June 14, 2004 10:11 PM

I went to the Yahoo groups and took a look at the photos. I have to say that I did not see any filaments. I was expecting to see something a little more obvious.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac 16

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

Having worked for several years in image processing I was wondering how much of the photos you started with were information and how much was noise.

For example, if an image has 8 bits of depth per pixel are there 4, 5, 6, or 7 bits of information. It is rare to have the lowest bit as actual information and in many imaging situations there are fewer than 6 bits of actual information. This means that the lowest 1, 2, and often 3 bits are noise, ie not information.

Image processing is often the task of making images more pleasing to the eye. This can be simple as in changing the brightness or contrast. Gamma is a simple change of pixel intensity in which the change is greater to darker pixels than to brighter pixels.

Suppose that the images are 6 bit images. That leaves 2 bits of noise. Alter the images so that 2 bits are information and 2 bits are noise and 4 bits are now nothing. What just happened to the information content of the image relative to the noise content?

Also, these images are JPGs. That is a lossy compression method. How has that changed the noise content of the images?

Check with the original source of the images to learn how much of the images is real and how much is noise. Knowing the quality of the images is important. Calibrating digital equipment is tricky. Lots of different techniques have been employed to adjust sensing equipment.

I am a bit curious about the means of viewing 3-d when the images are identical such as in viewing multiple tv screens. The composition of images into an internal 3-d view by the brain requires that the eyes see slightly different images. I sometimes work in a virtual reality lab here at VT. The CAVE produces 3-d worlds by supplying 24 image pairs to the eyes per second. A different image is rendered for each eye. The same is true when a head mounted display is used. Three-d movies do the same. Two televisions side by side or two telescope images side by side are not going to create the 3d effect since the images do not differ.

SIRDS (single image random dot stereograms) produce a 3-d effect, but rely on the use of noise and low resolution images to produce the effect. Two

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

superimposed images are laid over a noisy background.
The eyes separate the low resolution images from the
noisy background. The important point here is that
two differing images are imbedded in the single image.
This is still different than a tv image.

From: "Louise and Bob" coatsbob@yahoo.com
To: "Rich Murray" <rmforall@comcast.net>
Subject: Re: gamma
Date: Tuesday, June 15, 2004 8:43 AM

The important first step is to consider whether or not
the pattern in the images is real or not. This is
before there is any discussion of redshift or distance
or UV or anything else.

So now I am going to avoid discussing tangled webs of
distant objects and gravitational lensing
possibilities and everything else like that.

Step 1 is to see what gamma is all about. A common way
of computing gamma is as follows:

$$\text{new} = ((\text{old}/\text{max})^{\text{gamma}}) * \text{max}$$

Here max is the maximum value of a pixel. For
simplicity of discussion consider max to be 255 which
corresponds to the largest value when 8 bits are used.

Dividing a pixel by max maps the pixels from 0 to max
to the interval 0 to 1. Then the value is raised to
the gamma. The number is still between 0 and 1.
Multiplying the result by max stretches the data back
out to the 0 to max range, which here is 255. So back
to the original range of a pixel.

The gamma value is not the number you entered.
Typically it is 1/n, where n is the number you
entered. Because gamma correction is a point process
it is possible to precalculate what a pixel maps to.
By point process it is meant that each pixel is
independent of its neighbors. Local values do not
affect the result. Each pixel is on its own. I
attached graphs of the correction for gamma values of
2.5, 100, 200, and 300.

Here is what happens. The 2.5 graph is a typical
upper limit for corrections used with monitors. The
other graphs are effectively identical. Take a look
at the left side in the range 0 to 8. Assume 3 bits

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

of noise. Noise is now raised to the level of bright.

The 5 bits above the noise are all 0. There should not be anything in the image, yet applying gamma effectively shoves the noise pixels into the visible range.

I think it is rather clear that the use of large gamma values on these pictures is generating nothing, but noisy images.

If you want to dispute this you might try something like the following:

Take all of the pixels in the image. Count how many bits are on and off. For example, take the highest bit. How often is it 1 and how often is it 0? If the bit is a noise bit it is conceivable that the number times that the bit is 1 is approximately equal to the number of times it is 0. Compare these results to the results for lesser bits.

There is no 3-d possibility from identical images. The 3-d effect is based on the differences, apparent shifts, between the objects in the images. There are lots of optical tricks that can be played on the mind. Try this one. Take a pattern of random dots. Duplicate it. Shift the second patterns a small amount relative to the first random dot pattern. What do you see? Is this real or an artifact of the way in which the visual system tries to make sense of potential patterns.

bob

a friendly introduction: Beohringer: Murray 2004.06.12

2004 June 12 Hello Bob,

I enjoyed your website on stereology. You might be interested in my simple analysis of mysterious background filaments in very deep cosmological photos, for which I set up a group over two years ago. I am organizing myself to offer a post on recent images.

"About two decades ago I noticed that when the same photo is set up side by side, and viewed with slightly crossed eyes to make a third composite image in between, that image is created by the brain's visual system as an excellent 3D image. In fact, you can visit a TV store, where a lot of sets are all on the same channel at once, and find two sets the same size, side by side,

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

and watch the composite image in moving 3D. If you settle your gaze gently for a few minutes into the composite image, the innate image processing facility of the brain's visual system will develop and deepen the 3D appreciation in remarkable and beautiful ways."

deep sky background filaments: images and interpretation 2002.01.19:
Murray rmforall

<http://groups.yahoo.com/group/AstroDeep/1>
<http://photos.groups.yahoo.com/group/astrodeep/1st?.dir=/&.view=t>

Click on the thumbnail photos to get the photos, and click on those in turn to get full screen photos.

Artifacts? Or?— immense filaments of H, He, and dark matter, lit by intense UV from the earliest very massive stars, "...during the first 10E8 years of the history of the universe at redshifts between 50 and 10...",
Prof. Richard B. Larson, Sci. Am. Dec 2001, and
<http://www.astro.yale.edu/larson/papers/Noordwijk99.pdf>
[7 pages]. This very early intense UV is now redshifted into the visible and IR bands, and may supply about half of the current cosmic IR background. The filaments are generally as thin as 1 pixel.

Photo #2: [deeptt1k.jpg](#):
One pixel = .258 arc-sec, about .25 mm on my 15" monitor.
In MGI PhotoSuite 4.0, I can zoom in to 1600 %, at which point each pixel is about 4 mm on my 15" monitor.

This is a 20KB cut from the center of the 673 KB original, Photo #1: [deeptt1.jpg](#):
1024X1024 pixels, a random sample, the first of three,
a little to the lower left of center of the 1.15X1.15 degree field,
16000X16000 pixels, 750.3 Mb 24-bit color TIFF,
the highest available resolution,
http://www.noao.edu/image_gallery/html/im0637.html
National Optical Astronomy Observatory Deep Wide-Field Survey.

----- Original Message -----
From: "bob" <rboehrin@vt.edu>
Newsgroups: bionet.neuroscience
Sent: Tuesday, May 25, 2004 5:43 AM
Subject: Use of stereology

> *How often do people make use of stereology in their research. If you
> do use it, do you use a software package or do you use a manual
> technique?*

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation 10m mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

<http://filebox.vt.edu/users/rboehrin/index.htm>

<http://filebox.vt.edu/users/rboehrin/Introduction/AboutAuthor.htm>

The Author

I am Robert Boehringer and presently living in Blacksburg, Virginia where I attend Virginia Tech. I have been enrolled in the Masters program for Computer Science as a part time student. My GPA is 3.90 (A=4.0 A-=3.7) Although part time I am an active student and attend as many of the lecture series as possible. I also make good use of the cultural opportunities that are available through the university.

I am employed by MicrobrightField, Inc. the leader in software for stereological research and serial reconstructions.

Outside of the school and work I have hobbies that include bird watching, hiking, traveling, and the occasional rock climb.

My motivation for creating information about stereology is due to the the lack of information available online. It also provides me the chance to record some of the observations I have made.

It is surprisingly easy to find misinformation about stereology. Examples are:

Suggestions to avoid proper sampling

Poorly done simulations

The use of ocular mathematics

The latter entry is in reference to a joke that several of us started in high school. It was suggested that the easiest math would be a discipline with a single axiom, "If it looks right, then it is right." It should come as no surprise that ocular mathematics is prevalent in many disciplines.

Stereology is no exception. I have seen corrections for numbers that are too large, generate even larger numbers. I have seen counting rules changed to forms that were more pleasing to the eye. I have seen assumptions made about averages that do not hold under even the simplest conditions. I cannot be certain in all cases, but I believe that the ocular axiom was invoked in all of these cases as well as many others.

Please send in suggestions or comments to rboehrin@vt.edu.

Tricouni Nail in the Needles of South Dakota

This page written by Robert Boehringer at Virginia Tech.

<http://www.sciencedaily.com/releases/2004/06/040614080542.htm>

http://www.eurekalert.org/pub_releases/2004-06/uocs-ndt061004.php

Public release date: 11-Jun-2004

Contact: Jacquelyn Savani jsavani@engineering.ucsb.edu
805-963-8324 University of California, Santa Barbara - Engineering

Newly devised test may confirm strings as fundamental constituent of matter, energy

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation from mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

Experimental verification would mean more spatial dimensions exist

Santa Barbara, Calif.—According to string theory, all the different particles that constitute physical reality are made of the same thing—tiny looped strings whose different vibrations give rise to the different fundamental particles that make up everything we know. Whether this theory correctly portrays fundamental reality is one of the biggest questions facing physicists.

In the June on-line Journal of High Energy Physics (JHEP), three theoretical physicists propose the most viable test to date for determining whether string theory is on the right track. The effect that they describe and that could be discovered by LIGO (Laser Interferometer Gravitational-Wave Observatory), a facility for detecting gravitational waves that is just becoming operational, could provide support for string theory within two years.

When physicists look at fundamental particles—electrons, quarks, and photons—with the best magnifiers available (huge particle accelerators such as those at Fermi Lab in Illinois or CERN in Switzerland), the particles' structures appear point-like. In order to see directly whether that point-like structure is really a looped string, physicists would have to figure out how to magnify particles 15 orders of magnitude more than the 13 orders of magnitude afforded by today's best magnifying techniques—a feat unlikely to occur ever.

In their paper "Cosmic F and D Strings," the three physicists propose looking instead for the gravitational signature of strings left over from the creation of the universe.

The physicists are Joseph Polchinski of the Kavli Institute for Theoretical Physics at the University of California at Santa Barbara (UCSB), Edmund Copeland of Sussex University in England, and Robert Myers of the Perimeter Institute and Waterloo University in Canada.

The international collaboration took place at a semester-long program on "Superstring Cosmology" held last fall at the Kavli Institute for Theoretical Physics (KITP). Located on the UCSB campus and supported principally by the National Science Foundation (NSF), the Kavli Institute brings together physicists worldwide to collaborate on deep scientific questions. According to Polchinski, who is a string theorist, the KITP program that produced the test for string theory was the first sustained effort ever to bring cosmologists and string theorists together to advance the newly emerging field of string cosmology. Two-thirds of the roughly 100 participants were string theorists; and the other third, astrophysicists.

In the mid 1980s Edward Witten, now at the Institute for Advanced Study in Princeton, asked whether miniscule strings produced in the early universe would grow with the universe to a size that would make them visible today. Witten answered his own question negatively by raising three objections to the idea. Because of subsequent developments, all three objections have in turn now been answered, according to Polchinski and his collaborators, who

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation 10m mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

dispelled the last objection and then proposed a way of detecting those strings.

The first objection depends on a property of strings called "tension," which is the mass of a string per unit length.

"One way to characterize that number," said Polchinski, "involves the gravitational effect of the string. If you look at a string end on while a couple of light rays go past it on either side, the light rays will bend towards the string. So light rays that started out parallel to each other will now meet at some angle. The heavier the string, the more those light rays will bend, and the bigger the angle."

When Witten first worked on the problem, string theorists thought that angle had to be one degree. If it were one degree, the satellite COBE (Cosmic Background Explorer) would have detected that imprint in the microwave background radiation, which pervades the universe and which was released when the early universe cooled enough for matter and energy to decouple some 300,000 years after the hot birth of the universe. The maps of the early universe that COBE produced show no such imprint and, furthermore, put an upper limit on that angle of no more than one hundredth of a degree. The satellite WMAP (Wilkinson Microwave Anisotropy Probe) has now reduced it to one thousandth of a degree.

In the mid-1990s string theory underwent profound developments. One of the consequences of those developments was the realization that the tension of the string and therefore its gravitational effect could be much less than had been thought when Witten made his initial calculation of the angle of separation between light rays affected gravitationally by a string.

Henry Tye of Cornell and his collaborators showed that in some string theory models the angle of separation would be between a thousandth of a degree and a billionth of a degree—far too small for COBE to have detected.

Tye and collaborators also demolished the second objection to cosmic strings having to do with "Inflation," which can be thought of as an intensification of the explosion and rapid expansion of the early universe following rapidly on the heels of the universe's genesis in the "Big Bang." Witten back in the '80s had argued that the strings produced by the Big Bang would be both heavy enough and produced so early that Inflation would have diluted them beyond visibility.

String theory presupposes nine or 10 spatial dimensions, that is six or seven more spatial dimensions than have heretofore been assumed to exist in addition to the one dimension of time. Some of the "extra" dimensions are thought to be curled up or compactified and therefore exceedingly small; and some, to be larger, perhaps infinite.

In his attempts to understand Inflation in terms of string theory, Tye and collaborators envisioned our reality as contained in a three-dimensional "brane" sitting in higher dimensional space.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation 16m mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

Branes, a key conceptual breakthrough discovered by Polchinski in 1995, are essential structures in string theory in addition to strings. Instead of being only one-dimensional like strings, branes can have any dimensionality, including one. One-dimensional branes are called "D1 branes or D strings." So there are essentially two types of strings— the heterotic string or "F" (for "fundamental") string, which physicists knew about prior to 1995, and the "D string," or one-dimensional brane.

Tye and collaborators explained Inflation in terms of a brane and an anti-brane separating from each other and then attracting back together and annihilating. So a brane and an anti-brane existing in the extra dimensions would thereby provide the energy responsible for Inflation. Everything existing afterwards—our universe—is the product of their annihilation. And, according to the Tye models, at the end of Inflation, when brane and anti-brane annihilate, not only does their annihilation produce heat and light, but also long closed strings that could grow with the expansion of the universe.

At the outset of the KITP program in fall 2003, the only remaining objection to cosmic strings was what Polchinski calls summarily "the stability argument," first made by Witten back in the '80s. If, on the one hand, the post-Inflation strings were charged, then they would pull back together and collapse before they could grow to any great size. If the strings weren't charged, then they would tend to break into pieces. Either way—collapsing or breaking—the strings couldn't survive until today.

Copeland, one of the JHEP paper's authors, went to a talk at the KITP by Stanford string theorist Eva Silverstein, who was interested in networking F and D strings—hooking them together to form something analogous to a wire mesh or screen. After the talk, Copeland wondered aloud to Polchinski whether Silverstein (who was thinking string theory mathematics, not cosmology) was inadvertently describing a mechanism for the dark matter—that as yet unidentified, non-radiating component of the universe which must exist in much greater abundance than all the ordinary "baryonic" matter of which we are aware.

Polchinski and Copeland worked out why Silverstein's scenario could not pertain to dark matter, but the engagement with that question got Polchinski to thinking about the old instability argument against the existence of cosmic strings in terms of Tye's brane-antibrane Inflation, particularly as worked out in detail by six physicists in a 2003 paper, "Towards Inflation in String Theory."

Using that model, Polchinski, Copeland, and Myers calculated the decay rates for cosmic strings and discovered how slow the rates could be—so slow in fact that the strings would survive to the present day. By "survive" they mean not just detecting the gravitational footprint left long ago in the cosmic microwave background and "seen" by looking back in time, but actually seeing the gravitational effects of cosmic strings existing if not now, then billions of years after the genesis of the universe.

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation 24m mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

Polchinski said their calculations showed that both F and D cosmic strings could exist and that the JHEP article explains how to distinguish the signature of one from the other. He also pointed out that Gia Dvali (New York University) and Alexander Vilenkin (Tufts University) have independently made the same point about cosmic D strings in March in another on-line publication, the Journal of Cosmology and Astroparticle Physics (JCAP).

Finally and most importantly, the JHEP authors show, said Polchinski, "how we can see cosmic strings. They are dark, but because they are massive and moving pretty fast, they tend to emit a lot of gravitational waves."

During the "Superstring Cosmology" program at the KITP, Alessandra Buonanno (Institut d'Astrophysique de Paris) provided an overview of the possible gravitational wave signatures from the early universe. "When she gave the talk," said Polchinski, "I didn't pay careful attention because I wasn't thinking about that, but later I went back to her talk in the KITP online series and started clicking through and got to where she talked about gravitational waves from cosmic strings. She had these curves which were quite amazing."

The large-scale, long-term experiment to detect gravitational waves has three stages, LIGO I and II and the satellite LISA, with each successive stage affording a markedly higher degree of sensitivity. Most of the gravitational signatures of cosmic events are so weak that they will probably only be visible in the later stages of the experiment. But, according to Polchinski, "the gravitational signatures from cosmic strings are remarkable because they are potentially visible even from the early stages of LIGO! That means 'potentially visible' over the next year or two."

Gravitational waves have yet to be directly detected, which is the mission of the LIGO and LISA experiments. So in addition to the possibility of confirming string theory, the JHEP paper offers a better target for initial LIGO detection of gravitational waves than any other from cosmic events.

Identifying the gravitational signature of cosmic strings is the work of Vilenkin and Thibault Damour (Institut des Hautes Etudes Scientifiques, France). They figured out that when cosmic strings oscillate, every once in a while, they crack like a whip. "It's surprising," said Polchinski, "but when you write out the equations for an oscillating string, a little piece of the string snaps and moves very fast. Basically, the tip will move at the speed of light. When a string cracks like this, it emits a cone of gravitational waves, which is a remarkably intense and distinctive signal, which LIGO can detect."

Polchinski said that the biggest question mark in the whole argument has to do with the stability of the strings over billions of years. But, he added, "There has been a fair amount of discussion about the signature of string theory in cosmology, this is by far the most likely. What excites me most is how much we could learn about string theory if LIGO were to detect the signal from cosmic strings."

visible cosmic network of deep sky filaments ("Murray mesh") as redshifted hard gamma radiation 25m mac

ray mesh") as redshifted hard gamma radiation from macroscopic cosmic F- and D-strings from epoch just after inflation (

<http://groups.yahoo.com/group/aspartameNM/message/1071>

research on aspartame (methanol, formaldehyde, formic acid) toxicity:

Murray 2004.06.18 rmforall

Rich Murray, MA Room For All rmforall@comcast.net

1943 Otowi Road, Santa Fe, New Mexico 87505 USA 505-501-2298

[NutraSweet, Equal, Canderel, Benevia, E951]

<http://groups.yahoo.com/group/aspartameNM/message/927>

Donald Rumsfeld, 1977 head of Searle Corp., got aspartame FDA approval:

Turner: Murray 2002.12.23 rmforall
