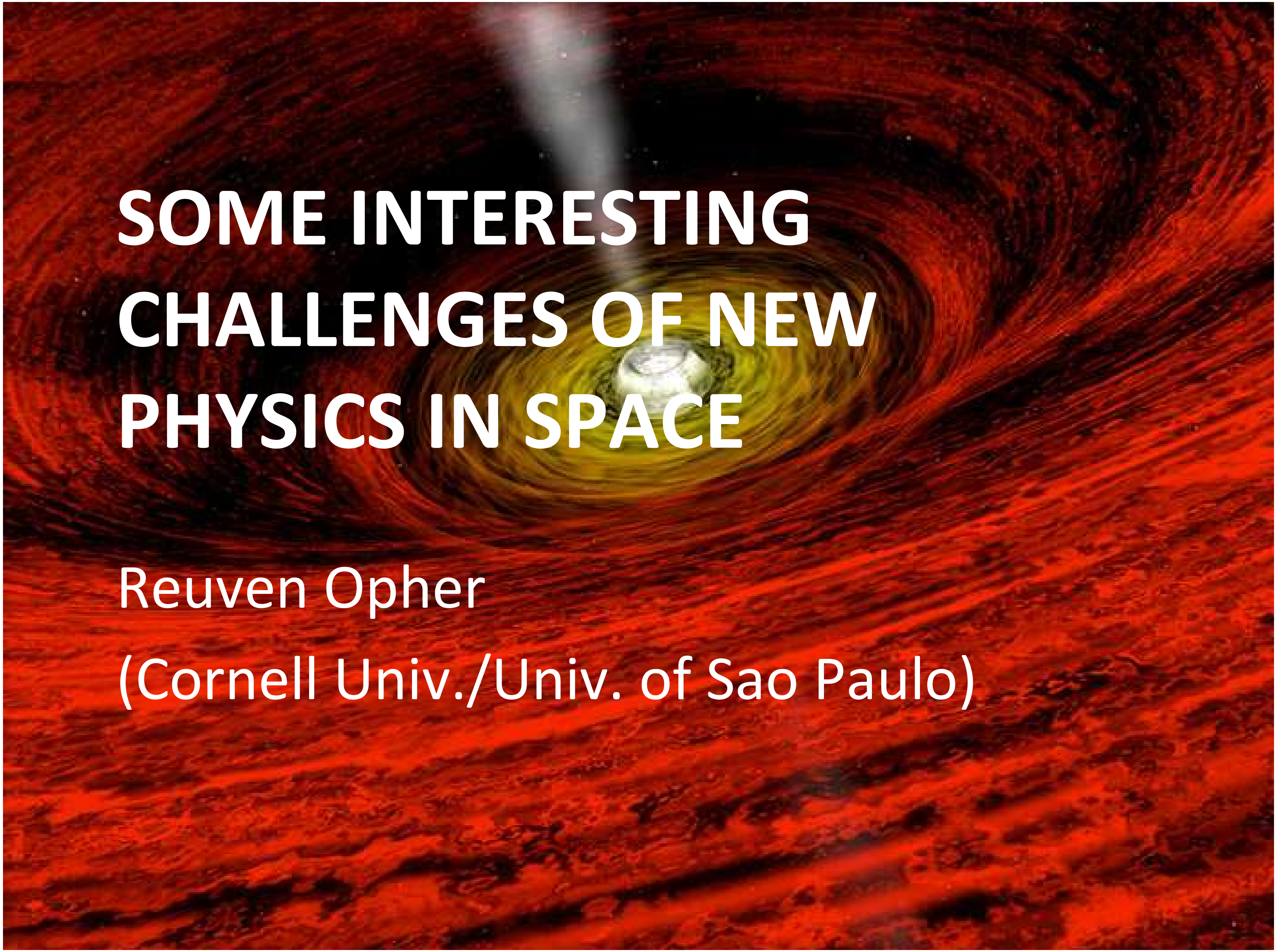

SOME INTERESTING CHALLENGES OF NEW PHYSICS IN SPACE

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OVER THE YEARS WE INVESTIGATED THE FOLLOWING TWELVE INTERESTING CHALLENGES OF NEW PHYSICS IN SPACE.

CHALLENGE (1)

WHAT IS THE ORIGIN OF THE UBIQUITOUS MAGNETIC FIELDS IN THE UNIVERSE?

Microgauss magnetic fields are observed in high and low redshift galaxies. Is a primordial origin indicated?

CHALLENGE (1)

OUR REPLIES: VARIOUS POSSIBILITIES

(A) Magnetic fields are produced due to plasma fluctuations in the early universe, where there is a peak in the magnetic fluctuations at zero frequency.

M. Opher and R. Opher, Phys. Rev. 56, 3296 (1997)

M. Opher and R. Opher, Phys. Rev. Lett. 79, 2628, (1997)

R.S. de Souza and R. Opher, Phys. Rev. D 77, 043529 (2008)

R.S. de Souza and R. Opher, Phys. Rev. D 81, 067301 (2010)

CHALLENGE (1)

(B) Magnetic fields are produced due to the collimating magnetic fields in extragalactic jets spreading out into the intergalactic medium (a magnetic field in the intergalactic medium will remain there for the age of the universe).

L.C. Jafelice and R. Opher, MNRAS 257, 135 (1992)

CHALLENGE (1)

(C) Magnetic fields are produced due to density gradients not being parallel to temperature gradients in primordial supernova explosions.

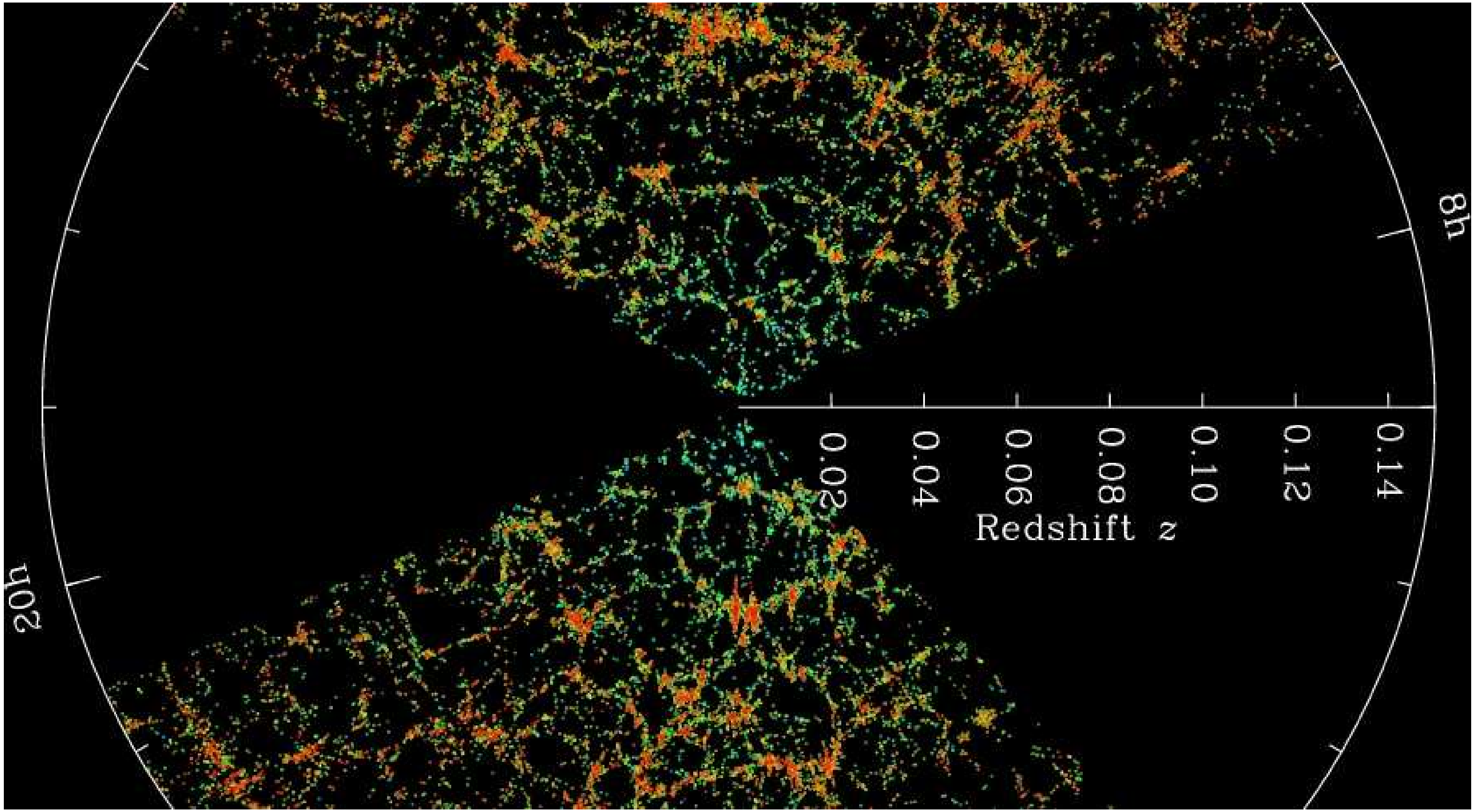
O.D. Miranda, M. Opher and R. Opher, MNRAS 301, 547 (1998)

CHALLENGE (2)

WHAT IS THE ORIGIN OF THE LARGE VOIDS OF GALAXIES?

Large empty voids are observed, but the standard model do not predict them.

DISTRIBUTION OF GALAXIES WITH LARGE VOIDS



CHALLENGE (2)

How to explain that the Local Void contains a third of the volume but less than a tenth of the number of galaxies predicted by numerical simulations based on the standard model?

P.J.E. Peebles and A. Nusser, Nature 465, 565 (2010)

OUR REPLY:

Large voids are produced by primordial supernovae.

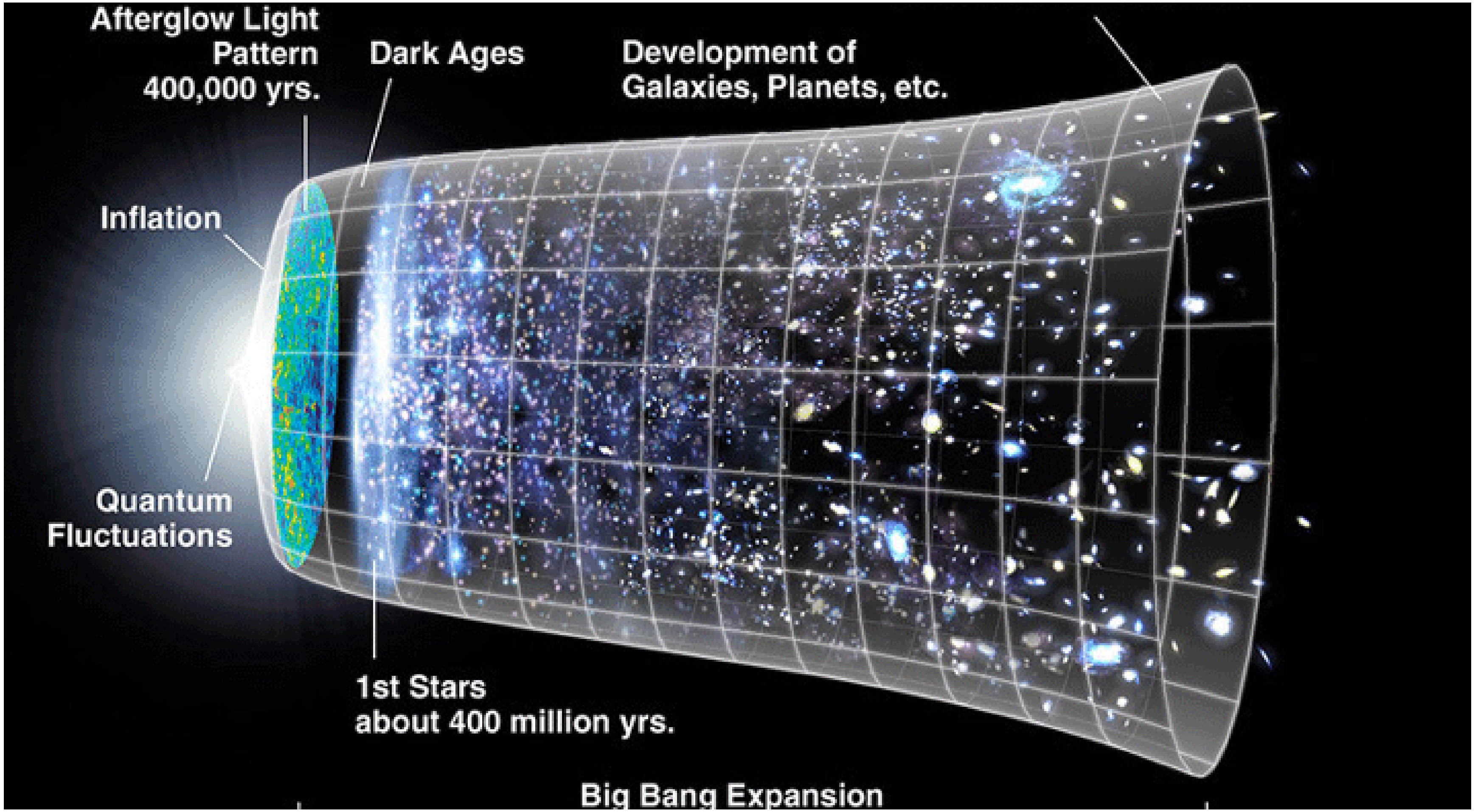
O.D. Miranda and R. Opher, MNRAS 283, 912 (1996)
O.D. Miranda and R. Opher, Ap.J. 482, 573 (1997)

CHALLENGE (3)

CAN A VIABLE PRIMORDIAL INFLATION PERIOD BE PRODUCED WITHOUT INFLATON FIELDS?

A primordial inflation period without inflaton fields with very flat potentials, that no particle has, is very desireable.

PRIMORDIAL INFLATION



CHALLENGE (3)

OUR REPLY:

One possibility is that the primordial inflation period could have been created due to Vacuum Fluctuations.

R. Opher and A. Pelinson, Phys. Rev. D 74, 023505 (2006)

(Starobinsky was the referee)

CHALLENGE (3)

A mass M is identified with the mass of the particles in the vacuum fluctuations.

The end of inflation is characterized by H oscillating rapidly with frequency ~ M, producing the reheating epoch.

Particles of mass comparable to M are produced in the reheating epoch.

CHALLENGE (3)

From the observed density fluctuations on large scales 10^{-5}, we made the prediction that

$M = 1.15 \times 10^{-6}\ M_{Pl}$

and the ratio of tensor to scalar fluctuations is

$r = 6.8 \times 10^{-4}$.

CHALLENGE (3)

A second possibility is a distorted energy-momentum relation $F(E) = E/Pc$ for relativistic particles.

We obtained the general conditions in order to produce an acceptable primordial inflation period.

U.D. Machado and R. Opher, Class. Quant. Grav. 29, 065003 (2012)

U.D. Machado and R. Opher, Phys. Rev. D (2013)

(in press)

CHALLENGE (4)

WHERE IS THE LARGE NUMBER OF PREDICTED SMALL DARK MATTER HALOS, WITH CUSP CENTRAL DENSITIES, WHICH IS NOT OBSERVED?

Do we not see them, because they don’t have any stars, or are they just not there?

CHALLENGE (4)

OUR REPLIES:

(A) The abundant small dark matter halos are there but we don’t see their stars because their baryon content was suppressed due to a primordial magnetic field.

L.F.S. Rodrigues, R.S. de Souza and R. Opher, MNRAS 406, 482 (2010)

R.S. de Souza, L.F.S. Rodrigues and R. Opher, MNRAS 410, 2149 (2011)

CHALLENGE (4)

OUR REPLIES:

(B) A suppression of the number of small halos occured due to a small change in the inflaton potential.

L.F.S. Rodrigues and R. Opher , Phys. Rev. D 82, 023501 (2010)

CHALLENGE (4)

OUR REPLIES:

(C) A supernova explosion occurred in a small dark matter halo which removed the baryons and transformed the dark matter cusp density distribution in the halo to a core distribution.

R.S. de Souza, L.F. S. Rodrigues, E.E.O. Ishida and R. Opher, MNRAS 415, 2969 (2011)

CHALLENGE (5)

CAN WE DETECT THE LOW ENERGY COSMIC NEUTRINO BACKGROUND USING A FIRST ORDER IN G FORCE, WHERE G IS THE WEAK COUPLING CONSTANT?

A force proportional to G may be the only viable way to detect the Cosmic Neutrino Background.

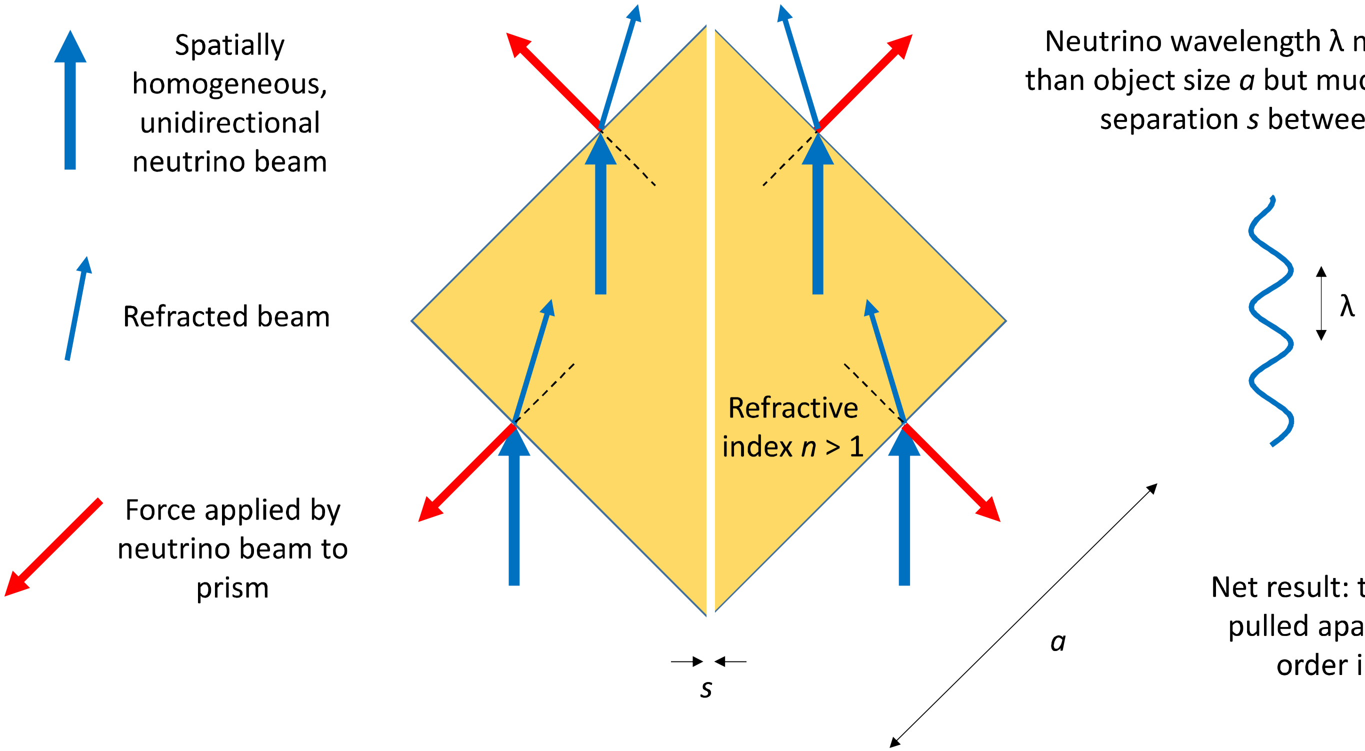
CHALLENGE (5)

OUR REPLY: YES

R. Opher, A&A 37, 135 (1974)

R. Opher and J. Riedel (2013)

CHALLENGE (5)



Spatially homogeneous, unidirectional neutrino beam

Refracted beam

Force applied by neutrino beam to prism

Refractive index $n > 1$

Neutrino wavelength λ much shorter than object size a but much longer than separation s between pieces

Net result: two pieces pulled apart to first order in G_F?

CHALLENGE (5)

With dimensions of the slabs 10m x 10m, velocity of the neutrinos ~ 300 km/s, slabs made of iron, neutrino mass ~ 2 eV, we obtain the force:

$F = 2.5 \times 10^{-14}$ dynes

This is similar to the force in the Dicke-Eotvos experiment.

P.G. Roll, R. Krotkov and R.H. Dicke, Ann. Phys. 26, 442 (1964)

CHALLENGE (6)

IS DARK ENERGY A SMALL VACUUM ENERGY?

All existing observational data are consistent with Dark Energy being a small vacuum energy, but how to justify theoretically a small vacuum energy?

CHALLENGE (6)

OUR REPLY:

A large vacuum energy could have decayed into a small present vacuum energy.

R. Opher and A. Pelinson, MNRAS 362, 162 (2005)

R. Opher and A. Pelinson, Braz. J. Phys. 35, 1206 (2005)

R. Opher and A. Pelinson, Phys. Rev. D 70, 063529 (2004)

CHALLENGE (7)

CAN MODIFIED GRAVITY REPLACE DARK MATTER IN GALAXIES AND

CAN IT BE TESTED IN THE LABORATORY?

Are the observed galactic rotation curves more consistent with Modified Gravity or Dark Matter theories? What are the conditions for a laboratory test?

CHALLENGE (7)

OUR REPLIES:

(A) Some modified gravity theories explain the observed rotation curves better than the standard model.

R.Opher, Braz. J. Phys. 31, 183 (2001)

CHALLENGE (7)

OUR REPLIES:

(B) We showed that the orbits in a Satellite Galaxy are unstable for small angular momenta in the direction of the Milky Way-Satellite Galaxy direction in the MOND Theory.

D. Muller and R. Opher, Ap. J. 540, 57 (2000)

CHALLENGE (7)

OUR REPLIES:

(C) A Modified Gravity theory such as MOND can be tested in the laboratory similar to the test that was made for Modified Gravity due to Extra Dimensions (C.D. Hoyle et.al., Phys. Rev. Lett. 86, 1418 (2001))

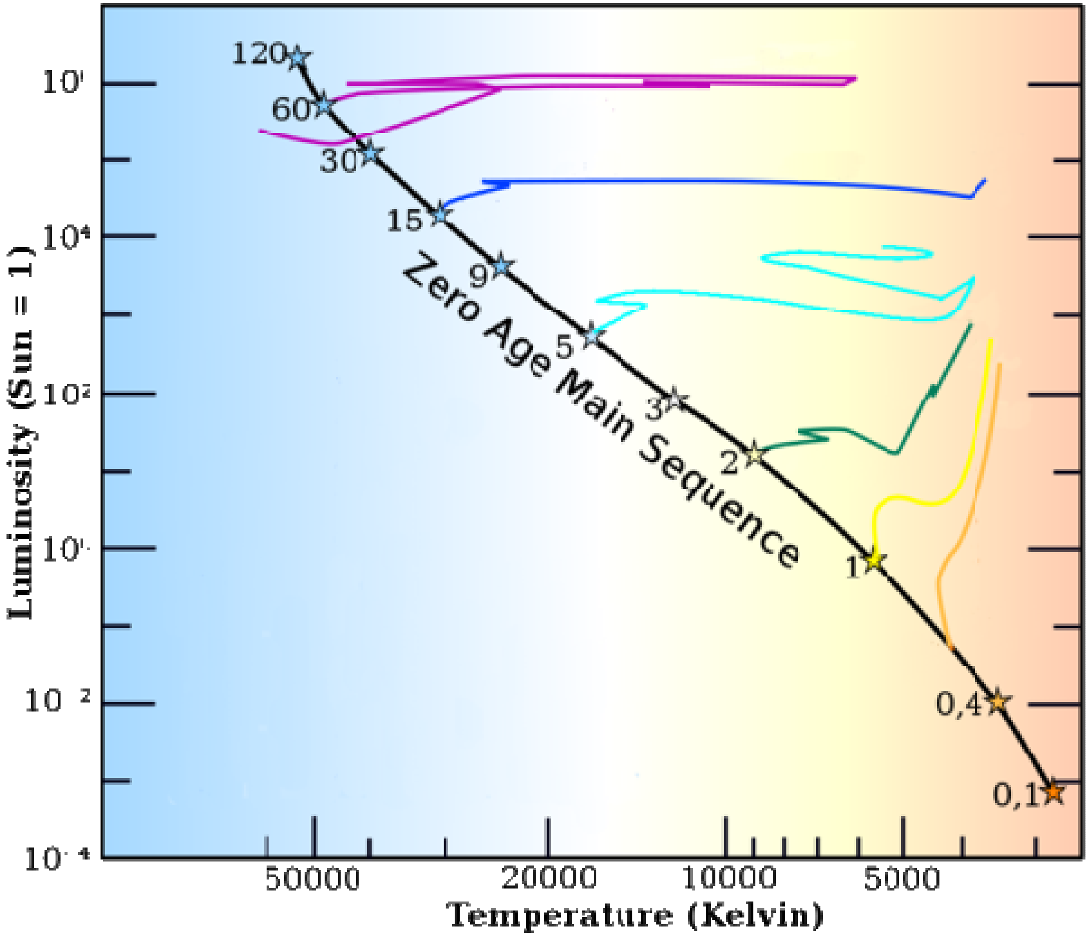
S.O. Mendes and R. Opher, Phys. Lett. B 522, 1 (2001)

CHALLENGE (8)

WHAT ARE THE EFFECTS OF DYNAMIC SCREENING ON STELLAR NUCLEI , INSTEAD OF TIME AVERAGED SCREENING?

Dynamic Screening of stellar nuclei should effect, for example, the predicted luminosity versus temperature curves of stars.

THE CALCULATED LUMINOSITY VERSUS TEMPERATURE OF STARS



CHALLENGE (8)

Stellar evolution models generally assume time-averaged plasma screening of nuclear reactions (The Salpeter Approximation), but what is the effect of the actual Dynamic Screening of nuclei, where the nuclei are less screened?

OUR REPLY:

The predicted luminosity versus temperature of stars will be altered.

M. Opher and R. Opher, Ap. J. 535, 474 (2000)

CHALLENGE (8)

RECENT EXAMPLE DEMONSTRATING THE IMPORTANCE OF DYNAMIC SCREENING:

K. Mussak and W. Dappen (Ap.J. 725, 96 (2011)) conclude:"..dynamic screening in solar p-p reactions does not reproduce the enhancement rates that is predicted by Salpeter's static screening approximation."

CHALLENGE (9)

CAN BLACK HOLES, FORMED FROM THE COLLAPSE OF MASSIVE STARS, BE THE ORIGIN OF GAMMA RAY BURSTS?

Can the Black Holes produce the large required accelerating potentials in the high predicted dense plasmas?

A GAMMA RAY BURST

CHALLENGE (9)

OUR REPLY:

Rotating Black Holes (RBHs) or Charged Black Holes (CBHs) from collapsed stars cannot be the origin of Gamma Ray Bursts due to the high predicted plasma densities which short circuit any potential differences.

The mean free path of the electrons is found to be always greater than the thickness of the shell necessary to short circuit the RBH or CBH.

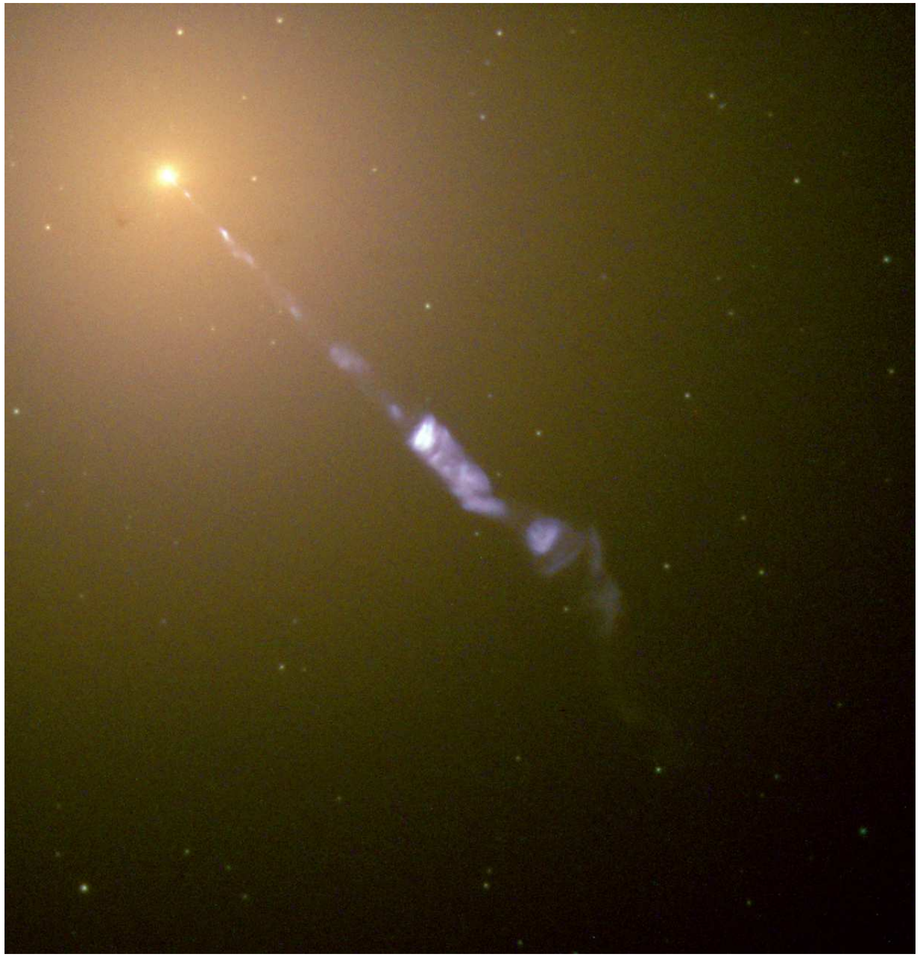
R. Opher, AIPC 840, 76 (2006)

CHALLENGE (10)

WHAT IS THE ORIGIN OF THE EXTREMELY WELL COLLIMATED RELATIVISTIC JETS?

We need a collimator that doesn’t allow the jets to spread as they propagate.

THE M87 COLLIMATED RELATIVISTIC JET



CHALLENGE (10)

OUR REPLY:

The jets are magnetohydrodynamically confined.

L.C. Jafelice, R. Opher, A.S. Assis and J.Busnardo-Neto, Ap. J. 348, 61 (1990)

CHALLENGE (10)

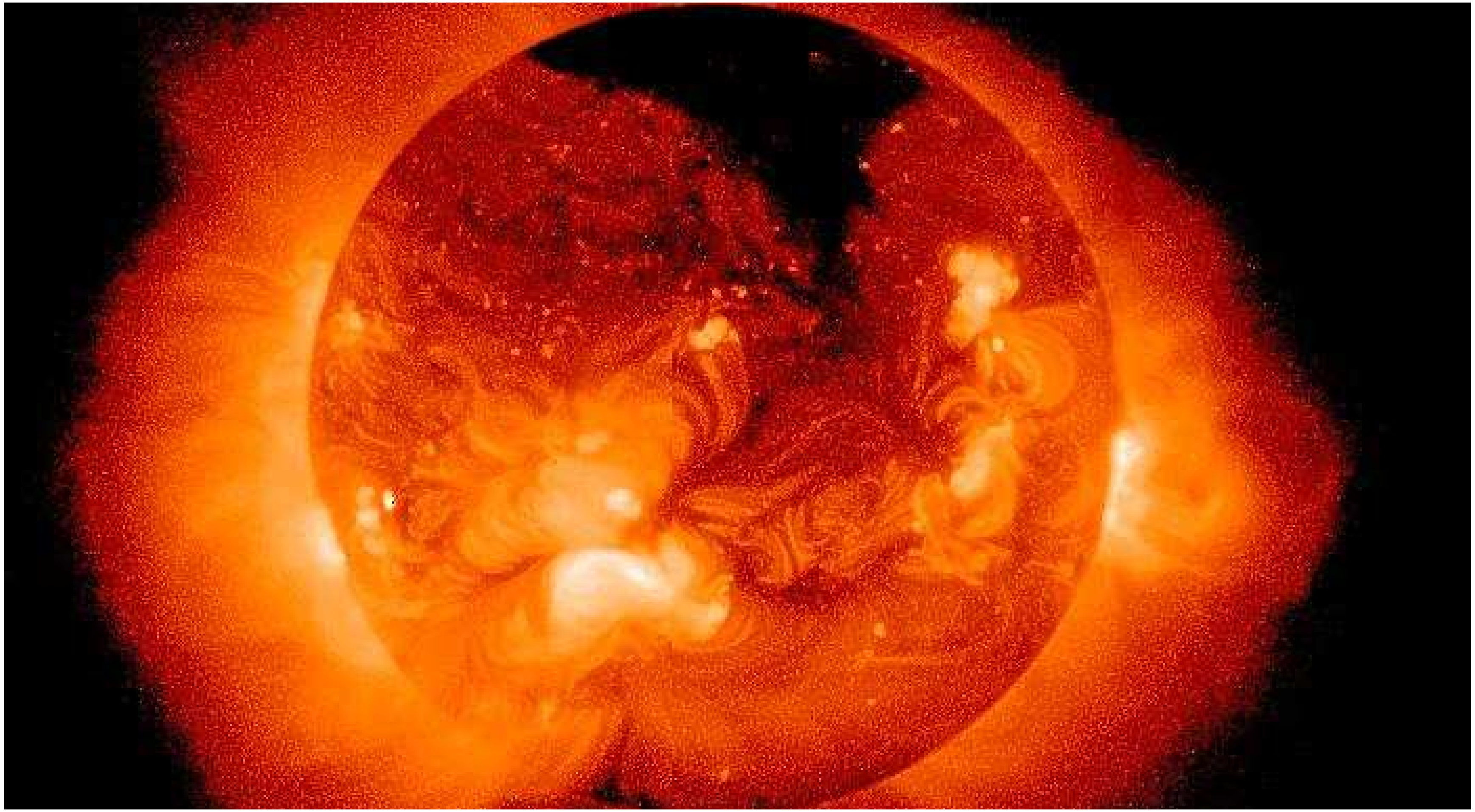
Due to MHD magnetosonic waves, produced by the Kelvin-Helmholtz Instability in the jet, we showed that transit-time magnetic damping of the waves produces an electric current that is dynamically important, sufficient to create a confining magnetic field for the relativistic jet.

CHALLENGE (11)

WHAT IS THE ORIGIN OF THE HIGH TEMPERATURE SOLAR CORONA?

We need a heat source that heats the solar corona to a temperature a thousand times higher than the solar photosphere.

THE HOT SOLAR CORONA



CHALLENGE (11)

OUR REPLY:

Heating with Alfven waves

V. Jatenco-Pereira, R. Opher and L.C.Yamamoto, Ap. J. 432, 409 (1994)

V. Jatenco-Pereira and R. Opher, MNRAS 236, 1, (1989)

M.J. Vasconcelos, V. Jatenco-Pereira and R. Opher, Ap.J. 534, 967 (2000)

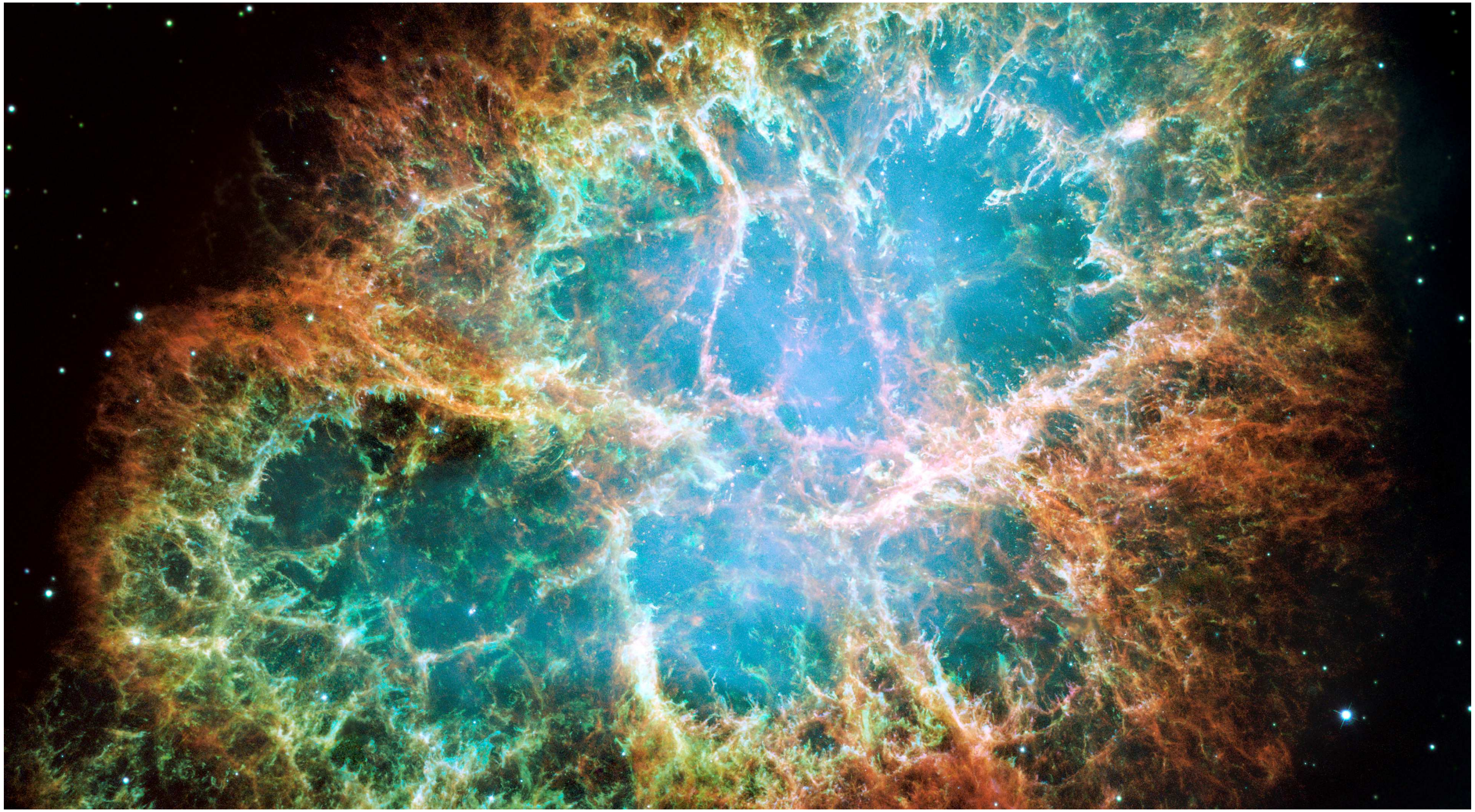
CHALLENGE (11)

We showed that, using the observed Alfven wave spectrum and amplitudes at 0.3 AU from the Sun, we could explain the observed required coronal heating.

CHALLENGE (12)

WHAT CREATES THE FILAMENTS IN THE CRAB NEBULA, WHERE ESSENTIALLY ALL THE MATTER IS IN THE FILAMENTS?

FILAMENTS IN THE CRAB NEBULA



CHALLENGE (12)

In the case of the Crab Nebula, the process leading to the formation of the filaments has been so efficient that it left less than 0.005 solar masses in the form of diffuse matter spread uniformly over the nebula.

A.S. Wilson, MNRAS 157, 229 (1972)

CHALLENGE (12)

OUR REPLY:

The filaments are produced due to a thermal instability.

D.R. Goncalves, V. Jatenco-Pereira and R.Opher, Ap. J. 414, 57 (1993)

E.M. Gouveia Dal Pino and R. Opher, Astron. Astrophys. 231, 571 (1990)

E.M. de Gouveia Dal Pino and R. Opher, Ap. J. 342, 686 (1989)

E.M. de Gouveia Dal Pino and R. Opher, MNRAS 240, 573 (1989)

CHALLENGE (12)

The essence of the thermal instability can be understood by considering a perturbation which increases the density (n) and decreases the energy per particle (e) in such a way that the energy density and pressure do not change (nxe approximately constant).

If the net cooling rate increases in this perturbation because of the higher density, the energy per particle decreases further, the density increases, leading to a thermal instability.