THE FACTS OF LIGHT

by Tony Timm

Scientific Heresy

There are no forbidden questions in science, no matters too sensitive or delicate to be probed, no sacred truths.

The Demon-Haunted World

Carl Sagan – Cornell & Harvard Universities.

The world always needs heretics to challenge the prevailing orthodoxies.

Heretical Thoughts About Science and Society.

Freeman Dyson - Professor of Physics at the Institute for Advanced Study, in Princeton.

Axiom

The speed of light in vacuum (c) is constant over all space.

Heretical Question

Is this really true ?

Metre – 1871 Definition

French Academy of Sciences
- Length of Quadrant on the Meridian through Paris.

North Pole

d = 10 million metres

Equator

Metre – 1983 Definition

Metre re-defined by the CGPM

- Distance travelled by light in vacuum in (1 / 299 792 458) of a second.

CGPM

Conférence Générale des Poids et Mesures

(General Conference on Weights and Measures)

Speed of light in Vacuum

Becomes automatically <u>exactly</u> defined.

$$c = 299\,792\,458.000 \text{ m/s}$$

(9 + Figure Accuracy)

Generalized Wave Equation

$$\nabla^2 \psi = (1/v^2) \, \partial^2 \psi / \partial \, t^2$$

Where

- ∇ -   3-D differential vector operator (grad)
  $(\partial/\partial x, \; \partial/\partial y, \; \partial/\partial z)$

- ψ -   Any 3-D vector wave function (Psi)
  (Vibration, sound, light, radio waves, microwaves)
  $[\; f_1(x,y,z,t), \;\; f_2(x,y,z,t), \;\; f_3(x,y,z,t) \;]$

- v   -   Velocity of the wave in the medium
- t   -   Time.

Comparison with E M Waves

<u>Generalized Wave Equation</u>

- $\nabla^2 \psi \qquad = \quad (1/v^2)\, \partial^2 \psi / \partial t^2$

<u>Wave Equations – Electric (E) & Magnetic (H) Fields</u>

- $\nabla^2 \mathbf{\underline{E}} \qquad = \quad (\mu\, \varepsilon)\, \partial^2 \mathbf{\underline{E}} / \partial t^2$
- $\nabla^2 \mathbf{\underline{H}} \qquad = \quad (\mu\, \varepsilon)\, \partial^2 \mathbf{\underline{H}} / \partial t^2$

Where

- μ -   Permeability of Medium
- ε -   Permittivity of Medium (Dielectric Constant)
- v -   Velocity of the wave in the medium

Hence

- $\mu\varepsilon \quad = \qquad 1/v^2$
- $v \quad = \qquad (\mu\varepsilon)^{-1/2}$

Speed of Light Equation
(Any Lossless Medium)

$$v = \frac{1}{\sqrt{\mu \, \varepsilon}}$$

Permeability

- The degree of <u>magnetization</u> of a material in response to a magnetic field.

$$\mu \quad = \quad k_\mu \, \mu_0$$

Where

- μ_0 – Permeability of Free Space (Vacuum)
- k_μ – Relative Permeability

Relative Permeability Range

Group	Material	k_μ
Ferromagnetic	Mumetal	100 000
	Transformer Iron	5 000
Paramagnetic	Aluminium	1.000 000 65
Non-magnetic	**Free Space & Air**	**1.000 000 00**
Diamagnetic	Distilled Water	0.999 999 10

Permittivity / Dielectric Constant

- The ability of a material to <u>polarize</u> in response to an electric field, and thereby <u>reduce</u> the total electric field inside the material.

$$\varepsilon \quad = \quad k_\varepsilon \, \varepsilon_0$$

Where

- ε_0 – Permittivity of Free Space (Vacuum)
- k_ε – Relative Permittivity

Relative Permittivity Range

Material	k_ε
Barium Titanate (Ceramic)	1 200
Distilled Water	80
Fused Quartz (Glass)	3.8
Free Space & Air	1.0

Medium of Free Space

For Free Space / Vacuum

$$c = (\mu_0 \varepsilon_0)^{-1/2}$$

$$= 2.997\ 924\ 580 \times 10^8\ \text{m/s}$$

- $\mu_0 = 4\pi \times 10^{-7}\ \text{H/m}$ (By Definition)
  $$\approx 1.256\ 637\ 061 \times 10^{-6}\ \text{H/m}$$
- $\varepsilon_0 \approx 8.854\ 187\ 818 \times 10^{-12}\ \text{F/m}$

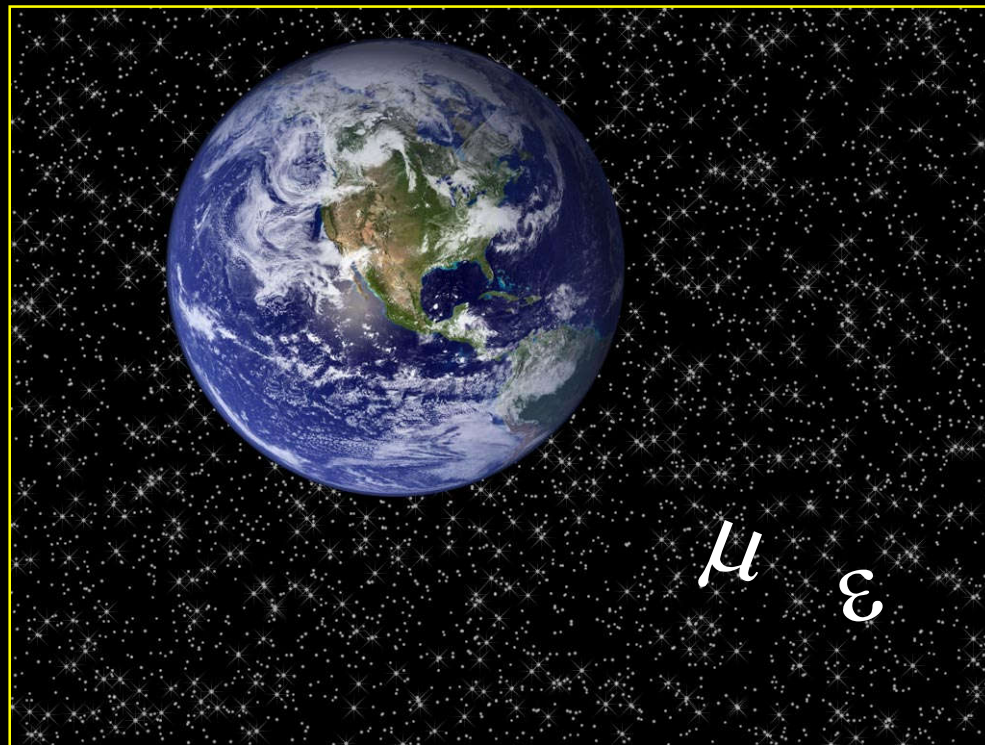# Relative Speed of EM Waves (Light) in different Dielectric Media

Material	k_μ	k_ε	v/c
Free Space & Air	**1.00**	**1.00**	**1.00**
Fused Quartz Glass	≈ 1	4	0.50
Distilled Water	≈ 1	80	0.11
Barium Titanate (Ceramic)	≈ 1	1 200	0.03

$$v/c = (k_\mu k_\varepsilon)^{-1/2}$$
$$c \approx 2.998 \times 10^8 \text{ m/s}$$

To "c" or not to "c": that is the question.

Apologies to Shakespeare

Hypothesis - Definition

- A proposition made as a basis for <u>reasoning</u> without assumption of its truth.

- A supposition made as starting-point for <u>further investigation</u> from known facts.

Concise Oxford Dictionary

Heretical Hypothesis

Because space has measurable
properties   (μ, ε)

- Space may not be "nothing"
- Space may indeed be "something".

It follows that

The parameters μ & ε <u>constrain</u> the speed of light to a finite value

If space were truly "nothing" – surely:

- <u>No</u> measurable properties
- <u>Nothing</u> to constrain the speed of light.

Further Reasoning

Since the speed of Light **is** constrained

to a finite value in space

Space may be

- A very subtle, but compressible medium

- Denser in stronger gravitational fields

- Less dense in weaker gravitational fields.

Implications

Permeability and Permittivity may be a function of the density of space

- Greater where space more dense
- Smaller where space less dense.

Speed of light may not be the universal constant we think it is

- Slower where space more dense
- Faster where space less dense.

Queries

Has the speed of light ever been measured

- Close to Jupiter or the Sun ?

- Outside the Solar System ?
  (Pioneer and Voyager Spacecraft)

If not - has it just been <u>assumed</u> that the

speed of light is constant over all space ?

> Recall specified accuracy
> c = 299 792 458.000 m/s

Is there any supporting evidence?

Bending of EM (Light) Waves

Apparent Position 1

Radio Waves

Pulsar
(1ms - 9s)

Path 1

Earth

Event
Horizon

Black Hole
(10^6 M$_\odot$)

Path 2

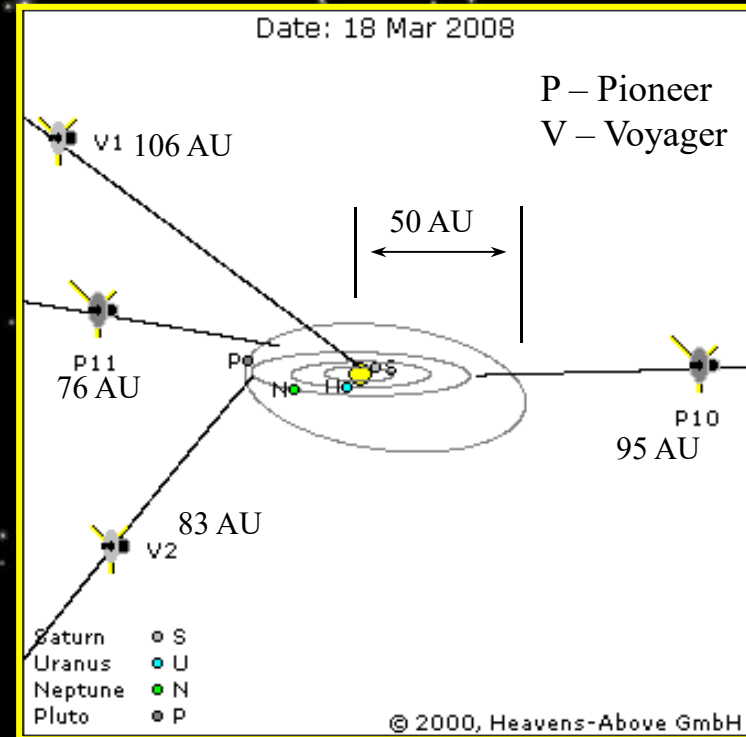**Apparent Position 2**
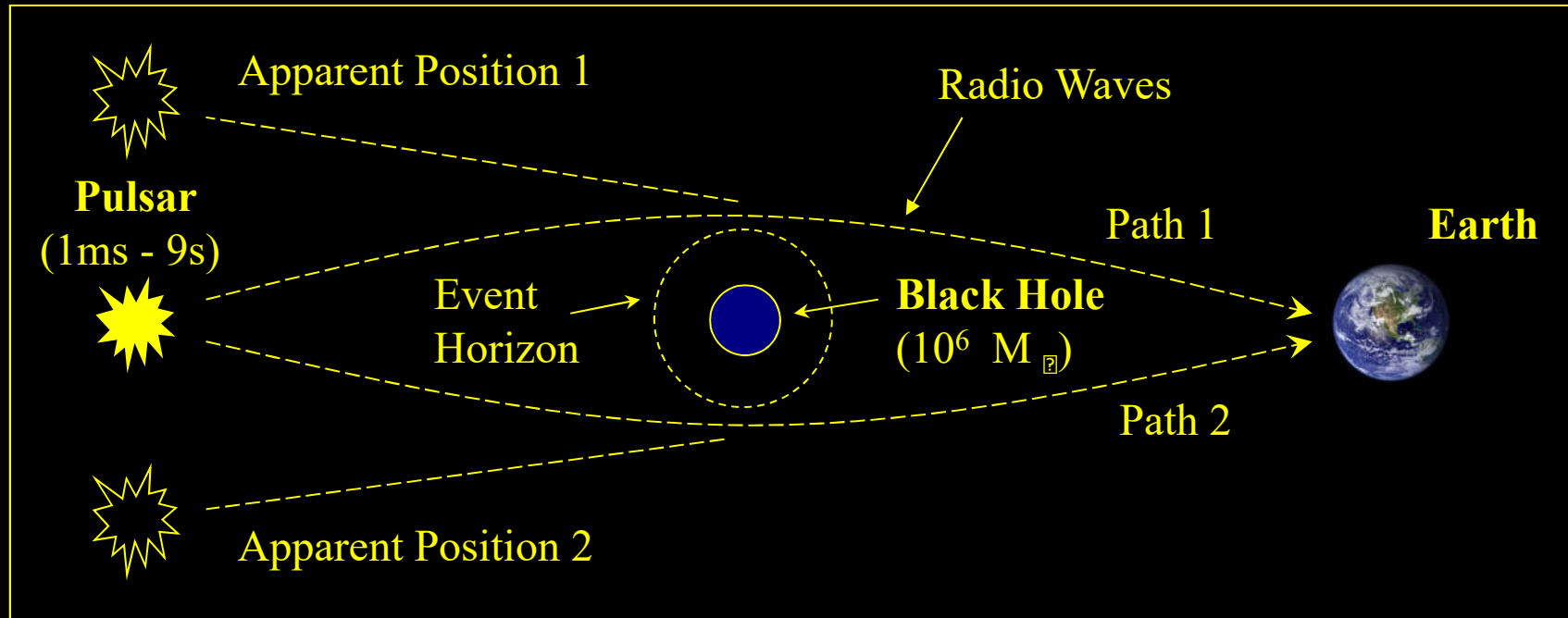
- Velocity of Light (Vector) – Magnitude & Direction
- Speed of Light (Scalar) – Magnitude only

Spacecraft Escaping the Solar System
(Pioneer & Voyager Crafts)

Date: 18 Mar 2008

P10

P – Pioneer
V – Voyager

So

U

N

Saturn   ○ S
Uranus   ○ U
Neptune   ○ N
Pluto   ○ P

P11   V2

V1

© 2000, Heavens-Above GmbH

Date: 18 Mar 2008

V1 106 AU

P – Pioneer
V – Voyager

50 AU

P11
76 AU

P10
95 AU

83 AU

V2

Saturn   ○ S
Uranus   ○ U
Neptune   ○ N
Pluto   ○ P

© 2000, Heavens-Above GmbH
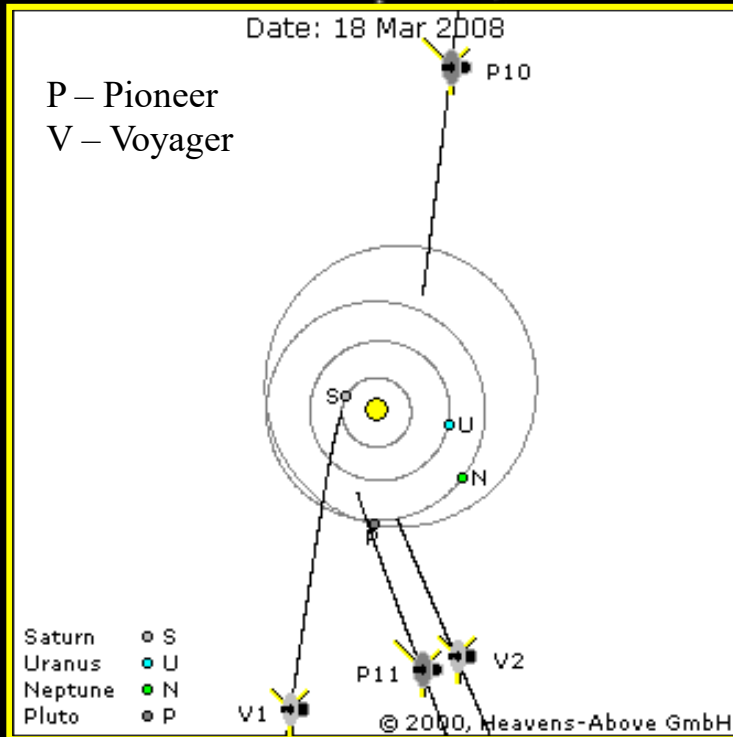
View of orbit from above ecliptic plane.

View from 10 degrees above ecliptic plane.

Developed and maintained by Chris Peat, Heavens-Above GmbH.
http://www.heavens-above.com/solar-escape.asp

Pioneer 10 & 11 Spacecrafts

- Launched 1972 & 1973

- Journeys outside Solar System

- Trajectories not as predicted

- Both about 400,000 kilometres off track when exiting Solar System.

Articles in *New Scientist* and *iTWire* - 2007

Proposed Causes - from Literature
(*Slightly Heretical*)

1) Gravitational effects of dark matter

2) Variable universal gravitational constant

$$F = G\, m_1 m_2 / r^2$$

$$G \approx 6.673 \times 10^{-11} \; Nm^2 kg^{-2}$$

Properties of Dark Matter

- It is <u>invisible</u>

- It does <u>not interact</u> with the electromagnetic force

- Trillions of dark matter particles <u>pass through</u> the Earth each second

- Its presence can only be <u>inferred</u> from its gravitational effects

- It comprises the <u>majority</u> of mass in the universe (> 90%).

Comments on Dark Matter

- There are <u>compelling reasons</u> to believe that dark matter exists.

- There is also <u>ongoing research</u> by scientists to discover exactly what dark matter is.
  e.g. <u>W</u>ilkinson <u>M</u>icrowave <u>A</u>nisotropy <u>P</u>robe (WMAP launched 2001 – maps CMBR)

- It has also been noted that the name "dark matter" serves mainly as an expression of human ignorance.

New Proposal
(*Very* *Heretical*)

Perhaps the Pioneer Craft Anomalies
are due to:

- Space Drag – from the density of space
  and / or
- Increased speed of light in less dense
  space.

Flight of Fantasy

- Quantification of effects?

- Order of magnitude approximation from Pioneer Data ?

If Discrepancy due to Increased Speed of Light

- Pioneer spacecraft - distance measurements were made between $z = 20$ AU and 70 AU from the Sun
  - Assume made at: $z_1 \approx 50$ AU   (7.5×10^9 km)
  - Apparent error: $\Delta z = 0.0027$ AU   (400 000 km)
  - Actual distance: $z_2 = z_1 + \Delta z$

- Time calculations assuming distance $= 50$ AU
  - To reach Earth: $t_1 = z_1/c \approx 24\,950.2$ s
  - Apparent error: $\Delta t = \Delta z/c \approx 1.3$ s

- Actual velocities of Light - at the Earth and from Pioneer
  - Earth (1 AU): $v_1 = c$ $= 2.9979 \times 10^8$ m/s
  - Pioneer Ave: $v_2 \approx z_2/t_1$ $= 2.9981 \times 10^8$ m/s

- If distances small enough $\Rightarrow$ Linear approximation
  $\Rightarrow$ <u>Average</u> speed $=$ <u>Actual</u> speed at half the distance (25 AU)

Mathematical Model for Variable Permittivity

Assume

Hypothetical model for ε in space

- $\mu \approx \mu_0$
- Variation mainly in ε
- ε related to Gravitational *Inverse Square* Law.

$$\varepsilon = E_1 + E_2 / z^2$$

Where

- E_i = Constants
- z = Distance

PERMITTIVITY AND SPEED OF LIGHT

Celestial Object	Distance from Sun (AU)	Inverse Square Law for Permittivity	
		$\varepsilon / \varepsilon_0$	v / c
Solar Corona	0.1	1.0053025	0.9973593
Mercury	0.4	1.0000013	0.9999993
Earth	1.0	1.0000000	1.0000000
Saturn	10.0	0.9999470	1.0000265
Heliosphere	100.0	0.9999464	1.0000268

Attempt to Verify Hypothesis

Study Sun's Spectrum

Rydberg formula

- Accuracy of R_H - 7 parts per trillion
- Predict wavelength (λ) of electron transition photons

Measure wavelength (λ) at Earth's surface

$\Rightarrow$ Calculate permittivity (ε) at Sun's surface.

Why the Sun?

- Spectrum can be measured from Earth's surface

- Sun's surface gravity $\approx$ 28 times Earth's

- Distance to Sun $\approx$ constant
  $\Rightarrow$ $\approx$ no Doppler effect

- Sun's <u>Hydrogen</u> Absorption Spectrum
  (H $\approx$ 75% of Sun's mass)

Spectrograph - Solar Spectrum

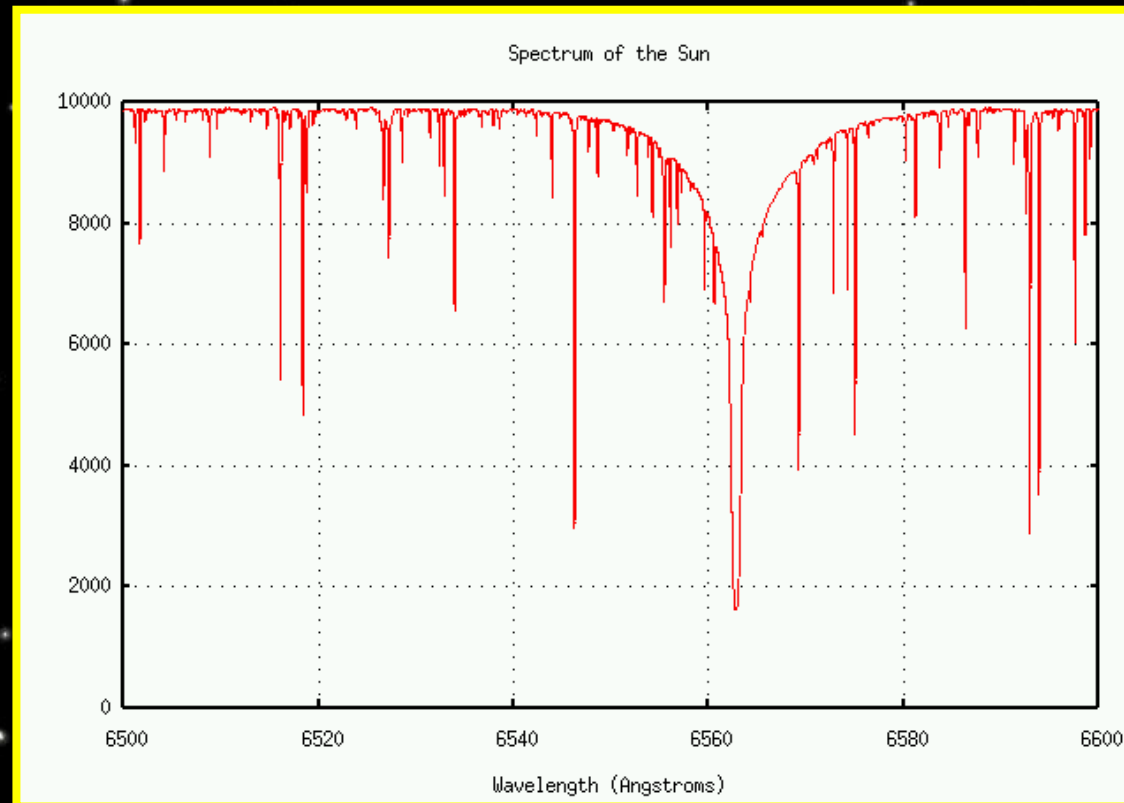The solar spectrum consists of a continuum with thousands of dark _absorption_ lines superimposed.

The Solar Spectrum
http://csep10.phys.utk.edu/astr162/lect/sun/spectrum.html
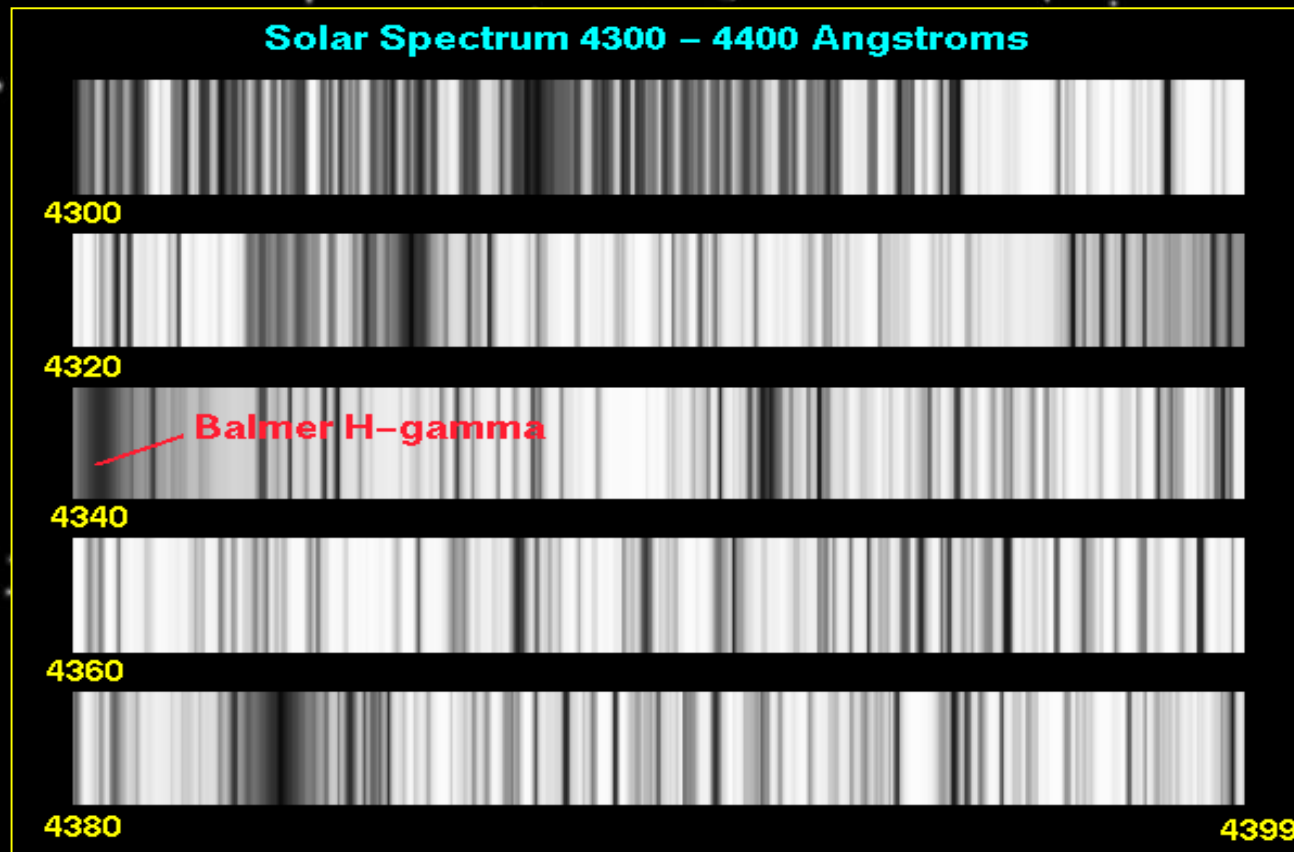
Intensity Graph - Solar Absorption Spectrum

- Main line in picture - Balmer Hα line

- From Rydberg formula - 6564.696 Å

The Shape of Spectral Lines. Michael Richmond

http://spiff.rit.edu/classes/phys440/lectures/lines/lines.html

Modus Operandi

Analysis

- Compared <u>measured</u> vs <u>theoretical</u> wavelengths for the <u>first 20</u> Balmer transition lines
  $(n_{LOWER} = 2, \quad n_{UPPER} = 3, 4, \ldots, 22)$

Objective

- Look for consistent bias toward <u>longer</u> wavelengths c.f. predicted values.

Results

- <u>No</u> transition lines coincided exactly with predicted values.

- In each case - <u>Zeeman Effect</u> splitting of lines about predicted value.
  (Electron spin - Sun's magnetic field)

- Comparison of Z-E line <u>midpoints</u> (λ_M) about <u>predicted</u> values (λ_P) $\Rightarrow$ large scatter.

  For <u>normalized</u> differences $\Delta\lambda_N = (\lambda_M - \lambda_P) / \lambda_P$

  Std Dev / Ave $\Delta\lambda_N$ =   36

Comments on
Analysis of Sun's Spectrum

- Uncertainties too great

- Results inconclusive

- Unable to make deductions.

Reason for Variances

Doppler-related wavelength changes

- Huge explosions at Sun's surface
- High velocity surges of material at Sun's surface (upward and downward).

Question Still Remains

Can it be said with absolute authority that

- **The speed of light is <u>constant</u> over all space?**

or that

- **The speed of light can <u>vary</u> in space?**

Another Flight of Fantasy

If true …
Implications ?

Light Years
(Distance Measurement)

- Assume that the <u>average</u> velocity of light from a star, (supposedly 100 light-years from Earth) is greater than c by a factor k.
  Then $v = k \cdot c$ $(k > 1)$

- Actual time to reach Earth = 100 / k years (not 100 years)

$\Rightarrow$ Only looking back in time 100 / k years

$\Rightarrow$ Age of Universe may be younger than current estimate (13.7 billion years).

Special Relativity Equations

Time Dilation

- $\Delta t' = \Delta t / (1 - v^2/c^2)^{1/2}$

Length Contraction

- $L' = L (1 - v^2/c^2)^{1/2}$

Redshift

- $1 + z = \lambda / \lambda_0$
  $= (1 + v/c) / (1 - v^2/c^2)^{1/2}$

And these are just the hors-d'oeuvres!

Summing Up

Solar Spectrum - Rydberg

- Large uncertainties
- Results inconclusive.

Pioneer Spacecraft Position Anomalies

- Not yet explained by science
  (Dark matter,   Variable G,   Density of Space?)

Conclusions

In order to establish the truth –

Need <u>direct</u> measurements in different strength gravitation fields of:

- Permeability
- Permittivity
- Speed of light

To Achieve This

Install instrumentation in spacecraft to measure these parameters.

Send spacecraft on journeys to:

- Strong gravitational fields
  (Near Sun & Jupiter)

- Weak gravitational fields
  (Beyond the solar system).

Final Comment

Concept of space density not stated as a truth
- only as an <u>hypothesis</u>.

Is this hypothesis not equally <u>plausible</u>
(or <u>suspect</u>) as that of
- **dark matter**   - or a -
- **variable gravitational constant** (G)
for explaining certain puzzling phenomena
in space?

However …

Of all these possibilities

- **Space density** is the only concept that could either be validated or disproved with existing technology.

References

- Howard W. Sams & Co., Inc. ITT Handbook, Reference Data for Radio Engineers. Fifth Edition.

- The Solar Spectrum 2935Å to 8770Å,
  Second Revision of Rowland's Preliminary Table of Solar Spectrum Wavelengths, by Charlotte E. Moore et al.

- Sci-Tech Dictionary: Rydberg constant
  http://www.answers.com/topic/rydberg-constant?cat=technology

- The Shape of Spectral Lines. Michael Richmond
  http://spiff.rit.edu/classes/phys440/lectures/lines/lines.html

- NewScientist.com news service, Michael Brooks

  13 things that do not make sense - 17 April 2007

  http://space.newscientist.com/article/mg18524911.600

- iTWire, Technology news and Jobs, Science,
  The Pioneer Anomaly: The NASA Whodunit, 29 March 2007
  http://www.itwire.com.au/content/view/10912/1066/