Science and Sublime: Two Ways of Viewing the World

Phillip F. Schewe   KITP   February 2016

Sublime: a term borrowed from painting by Romantic poets to suggest the grandeur of nature or exalted states of imagination

--This talk is NOT about religion

--It does NOT argue that art is better than science

(Painting: Caspar David Friedrich)

--I shall NOT read any of my own fiction

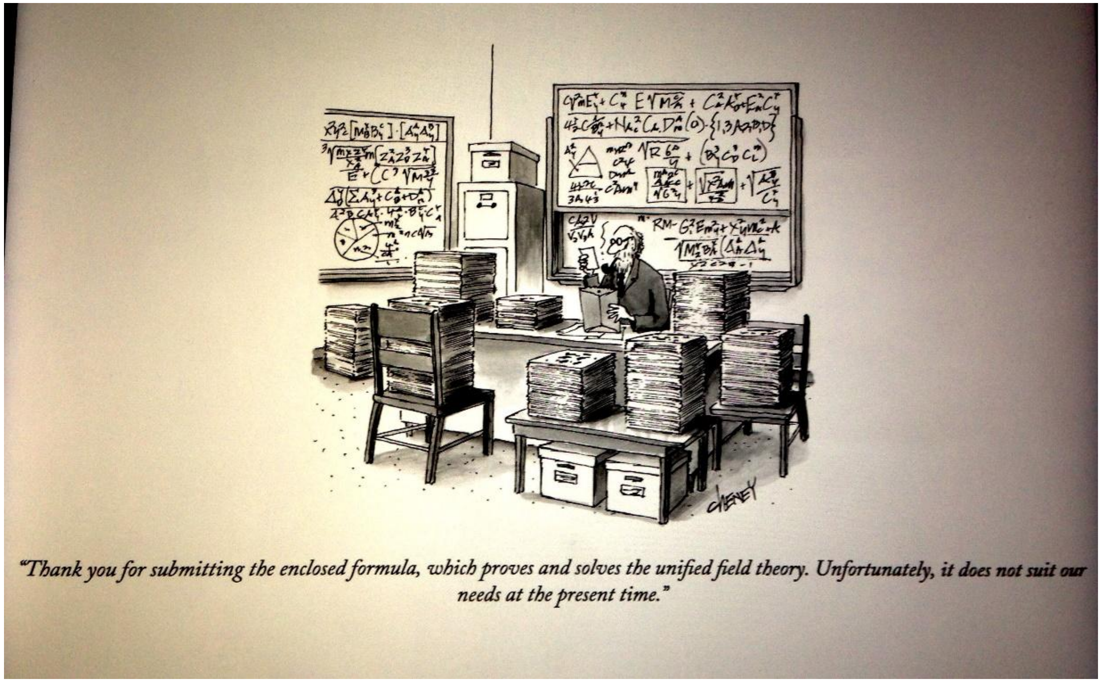
Contrasting attributes of science and literature

--Faraday induction

--Neutron waves

--quantum Hall effect

--Anomalous magnetic Moment



--Shakespeare

--Marcel Proust

--Emily Dickinson

--James Joyce

Nietzsche: foundations of Western Civ

Apollo

- Reason
- Truth
- Explain
- enlighten

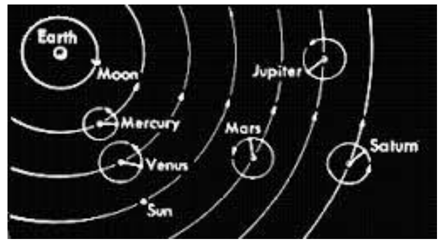
Dionysus

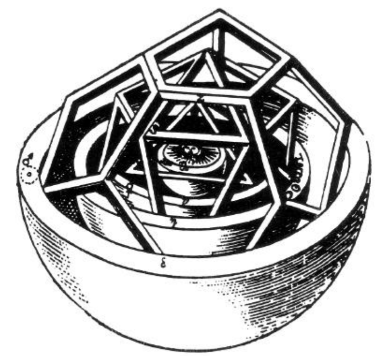
- Emotion
- Beauty
- Entertain
- enchant

better at explaining things

Early observations

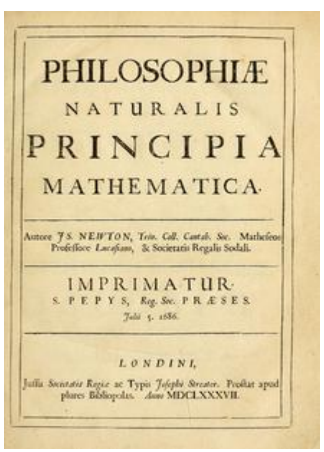
Ptolemy
(Greek geometry+
Babylonian data)





Kepler Part 1 (Platonic solids)
Kepler Part 2 (ellipses)

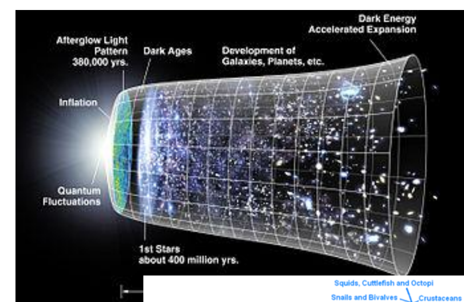
Newton


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

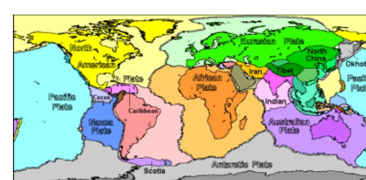
Autore JS. NEWTON, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.

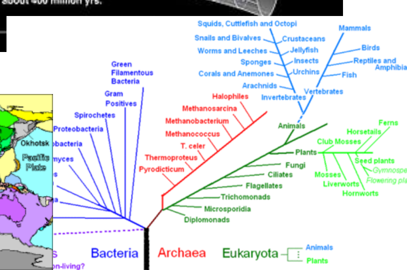
IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,
Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.



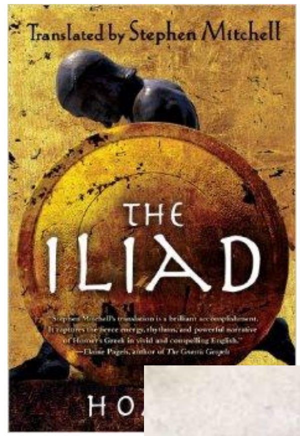
Standard Models





“Art never improves…but the material of art is never quite the same.” T.S. Eliot

Gilgamesh Akkad 2200 BCE



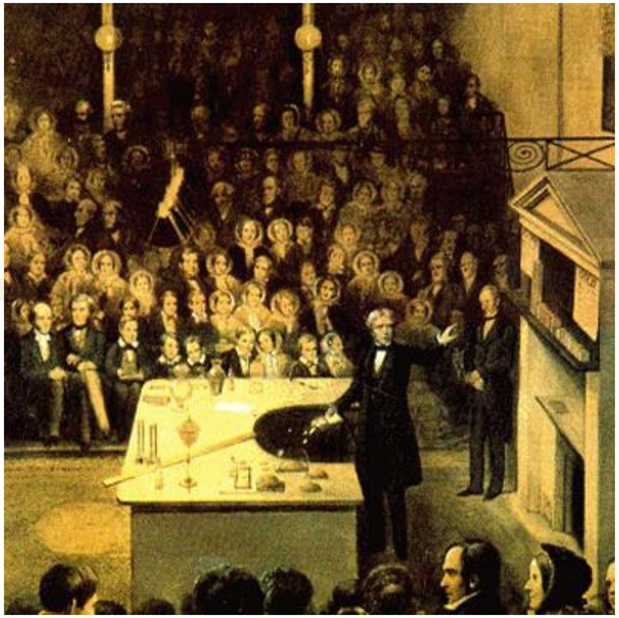
Iliad Greece 700 BCE

Shahmaneh Persia 1000 CE

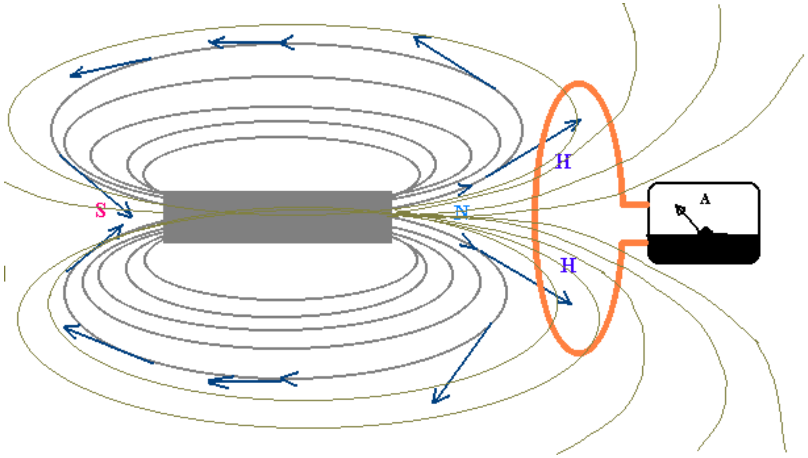
Journey to the West Ming China 1550

War & Peace Russia 1869

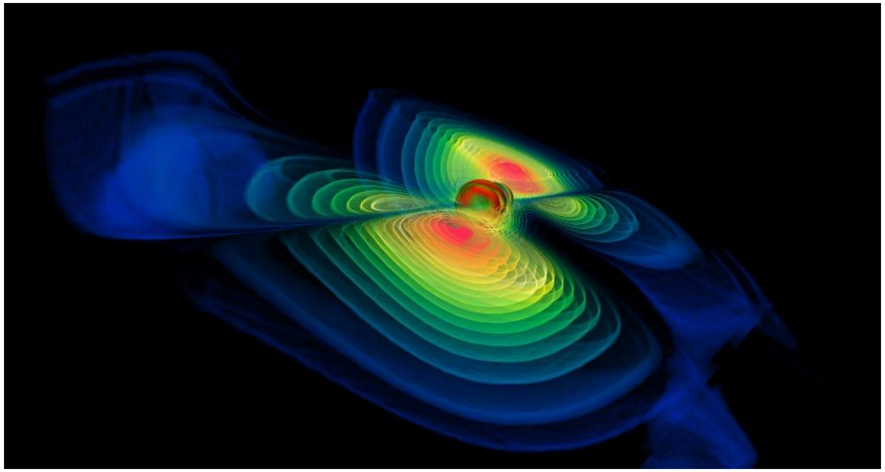
Scientific Discovery



Induction



Gravity waves



Literary Discovery

Harold Bloom;

SHAKESPEARE "DISCOVERS" personality

Sigmund Freud "discovers" the sub-conscious

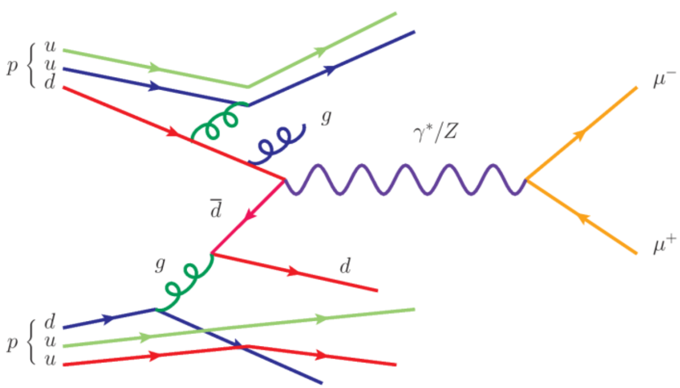
(Hamlet had an Oedipal Complex)

Science-to-sublime

Sigmund Freud: not a scientist but an anthropologist (Freud had a Hamlet complex)

Edward Gibbon: not a historian but a literary critic (Decline and Fall of the Roman Empire)

Quantum chromodynamics:
(will it be considered as art 200 years from now?)



Scientific knowledge: the burden of accuracy and explanation

LETTER

doi:10.1038/nature15265

Controlling neutron orbital angular momentum

Charles W. Clark[1], Roman Barankov[2], Michael G. Huber[3], Muhammad Arif[3], David G. Cory[4,5,6,7] & Dmitry A. Pushin[6,8]

The quantized orbital angular momentum (OAM) of photons[1] offers an additional degree of freedom and topological protection from noise. Photonic OAM states have therefore been exploited in various applications[2,3] ranging from studies of quantum entanglement and quantum information science[4–7] to imaging[8–12]. The OAM states of electron beams[13–15] have been shown to be similarly useful, for example in rotating nanoparticles and determining the chirality of crystals[16–19]. However, although neutrons—as massive, penetrating and neutral particles—are important in materials characterization, quantum information and studies of the foundations of quantum mechanics, OAM control of neutrons has yet to be achieved. Here, we demonstrate OAM control of neutrons using macroscopic spiral phase plates that apply a 'twist' to an input neutron beam. The twisted neutron beams are analysed with neutron interferometry. Our techniques, applied to spatially incoherent beams, demonstrate both the addition of quantum angular momenta along the direction of propagation, effected by multiple spiral phase plates, and the conservation of topological charge with

micrometres (ref. 23) depending on the transverse direction within the beam profile, while the beam diameter is about 15 mm.

The input to the interferometer (Fig. 1a) contains a mixture of OAM states and is spatially incoherent over the transverse displacement of the neutron paths. We adopt the strategy of using neutron interferometry to demonstrate coherent control of self-interfering neutrons. At any given time there is at most one neutron in the interferometer. How an SPP changes the angular-momentum composition of a wavefunction Ψ, can be thought of as follows. Upon transmission through the SPP, Ψ is simply modulated by the transmission amplitude $\Psi \to \exp(i\theta)\Psi$, where θ is the phase function of the SPP. Figure 1b is a schematic diagram of an SPP, and Fig. 1c is a photograph of two such plates (see details in Methods). As shown in Fig. 1b, the thickness of a SPP, h, varies with the angle, φ, so that $h = h_0 + h_s\varphi/(2\pi)$, where h_0 is the base height of the SPP and h_s is the step height. Interaction of low-energy neutrons with materials can be described using an optical potential[23]. Within this formalism, the phase shift with respect to vacuum of a neutron passing through an SPP is:

Journalism: reportable result, paint a physical picture, define terms

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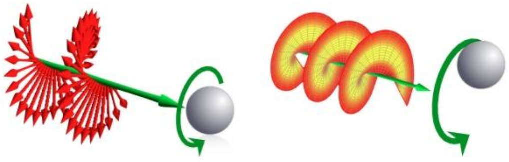
24 September 2015



Twisting Neutrons

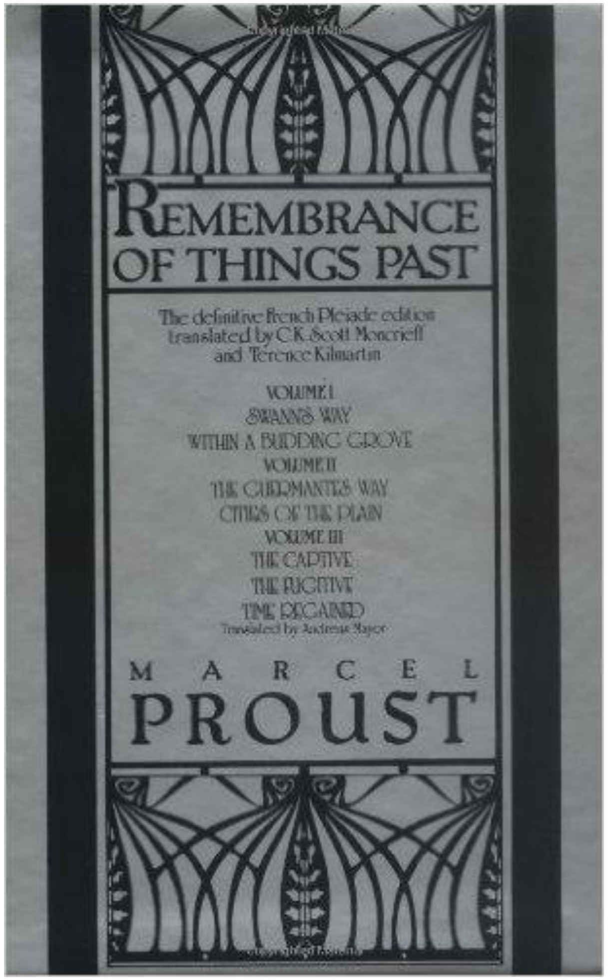
Orbital angular momentum of neutron waves can be controlled

It's easy to contemplate the wave nature of light in common experience. White light passing through a prism spreads out into constituent colors; it diffracts from atmospheric moisture into a rainbow; light passing across a sharp edge or a diffraction grating creates an interference pattern. It's harder to fathom the wave behavior of things usually thought of as particles, such as electrons and atoms. And yet these matter waves play a role in physics and in technology. For example, electron beams, manifested as waves, provide an important form of microscopy.

Neutrons, a basic constituent of atomic nuclei, have wave properties which are employed in a variety of research areas such as determining the structure of[illegible]ials. A recent experiment provides a new handle for control of neutrons by demonstrating that a quantum variable called orbital angular momentum is accessible in beams of neutron waves, and that it can be manipulated for use in neutron imaging and quantum information processing.

Fiction: What's it like to be other people?

- Is it entertaining?
- Beautiful?
- Truthful?
- Does it transport you?
- Ephiphany



Marcel Proust: involuntary memory

- …one day in winter, as I came home, my mother, seeing that I was cold, offered me some tea, a thing I did not ordinarily take. I declined at first, and then, for no particular reason, changed my mind. She sent out for one of those short, plump little cakes called 'petites madeleines,' which look as though they had been moulded in the fluted scallop of a pilgrim's shell.
- And soon, mechanically, weary after a dull day with the prospect of a depressing morrow, I raised to my lips a spoonful of the tea in which I had soaked a morsel of the cake. No sooner had the warm liquid, and the crumbs with it, touched my palate than a shudder ran through my whole body, and I stopped, intent upon the extraordinary changes that were taking place. An exquisite pleasure had invaded my senses, but individual, detached, with no suggestion of its origin.
- And at once the vicissitudes of life had become indifferent to me, its disasters innocuous, its brevity illusory—this new sensation having had on me the effect which love has of filling me with a precious essence; or rather this essence was not in me, it was myself. I had ceased now to feel mediocre, accidental, mortal. Whence could it have come to me, this all-powerful joy? I was conscious that it was connected with the taste of tea and cake, but that it infinitely transcended those savours, could not, indeed, be of the same nature as theirs.
- Whence did it come? What did it signify? How could I seize upon and define it? I drink a second mouthful, in which I find nothing more than in the first, a third, which gives me rather less than the second. It is time to stop; the potion is losing its magic. It is plain that the object of my quest, the truth, lies not in the cup but in myself. The tea has called up in me, but does not itself understand, and can only repeat indefinitely with a gradual loss of strength, the same testimony.

Theoretical Physics

PRL 115, 065301 (2015) PHYSICAL REVIEW LETTERS week ending 7 AUGUST 2015

Parafermionic Zero Modes in Ultracold Bosonic Systems

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(Received 21 April 2015; published 6 August 2015)

Exotic topologically protected zero modes with parafermionic statistics (also called fractionalized Majorana modes) have been proposed to emerge in devices fabricated from a fractional quantum Hall system and a superconductor. The fractionalized statistics of these modes takes them an important step beyond the simplest non-Abelian anyons, Majorana fermions. Building on recent advances towards the realization of fractional quantum Hall states of bosonic ultracold atoms, we propose a realization of parafermions in a system consisting of Bose-Einstein-condensate trenches within a bosonic fractional quantum Hall state. We show that parafermionic zero modes emerge at the end points of the trenches and give rise to a topologically protected degeneracy. We also discuss methods for preparing and detecting these modes.

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In recent years the concept of topological order has revolutionized the way we understand quantum phases of matter. Topological phases in one- and two-dimensional systems are particularly interesting as the nontrivial exchange statistics of particles allows for exotic states of matter. For example, Majorana zero modes can emerge at boundaries of one-dimensional topological superconductors [1] or in two-dimensional semiconductor heterostructures

with computationally universal braid statistics [27]. Parafermions may also be realized in bilayer quantum Hall systems, where the role of the superconducting-induced coupling is played by an interlayer tunneling term [28,29]. For a recent proposal on parafermions, see also Ref. [30].

While existing proposals are based on an experimentally challenging combination of FQH and superconducting systems of electrons, rapid advances towards creating a

Journalist's Burden to explain

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27 August 2015

Boson Fractional Quantum Hall Effect

The search for "zero-modes" in cold atoms

Looking outwards billions of miles, pictures from Pluto reveal unexpected mountains, fissures, and ice caps, and this stretches our concept of the solar system. Looking downwards at the microworld, we observe new states of matter, expanding our knowledge of fundamental interactions. The quantum Hall effect is an example. Discovered in the early 1980s this phenomenon was observed in a two-dimensional gas of electrons existing at the interface between two semiconductor layers. Subject to severe criteria of very high material purity and very low temperatures, and exposed to high magnetic fields, the electrons organize themselves into an ensemble state featuring remarkable properties.

Actually the quantum Hall effect comes in two forms according to whether the electrons interact strongly with each other or do not interact. The names are respectively the fractional quantum Hall (FQH) and the integer quantum Hall (IQH) effects.

Emily Dickinson

"If I feel physically as if the **top of my head** were taken off, I know that is poetry."

A CLOCK stopped---not the mantel's;
Geneva's farthest skill
Can't put the puppet bowing
That just now dangled still.

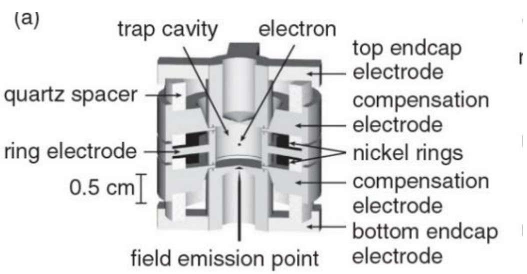
An awe came on the trinket!
The figures hunched with pain,
Then quivered out of decimals
Into degreeless noon.

It will not stir for doctors,
This pendulum of snow;
The shopman importunes it,
While cool, concernless No

Nods from the gilded pointers,
Nods from the seconds slim,
Decades of arrogance between
The dial life and him.

13,000 FEYNMAN DIAGRAMS

Gabrielse's electron



PRL 97, 030801 (2006) PHYSICAL REVIEW LETTERS week ending 21 JULY 2006

New Measurement of the Electron Magnetic Moment Using a One-Electron Quantum Cyclotron

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(Received 17 May 2006; published 17 July 2006)

A new measurement resolves cyclotron and spin levels for a single-electron quantum cyclotron to obtain an electron magnetic moment, given by $g/2 = 1.001\,159\,652\,180\,85\,(76)\,[0.76\text{ ppt}]$. The uncertainty is nearly 6 times lower than in the past, and g is shifted downward by 1.7 standard deviations. The new g, with a quantum electrodynamics (QED) calculation, determines the fine structure constant with a 0.7 ppb uncertainty—10 times smaller than for atom-recoil determinations. Remarkably, this 100 mK measurement probes for internal electron structure at 130 GeV.

Kinoshita's calculations

RIKEN-QHP-25

Tenth-Order QED Contribution to the Electron $g-2$ and an Improved Value of the Fine Structure Constant

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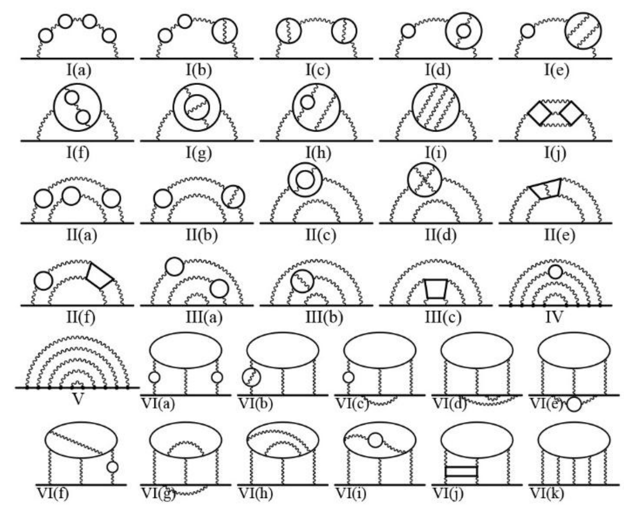
[4] *Laboratory for Elementary Particle Physics, Cornell University, Ithaca, New York, 14853, U.S.A*

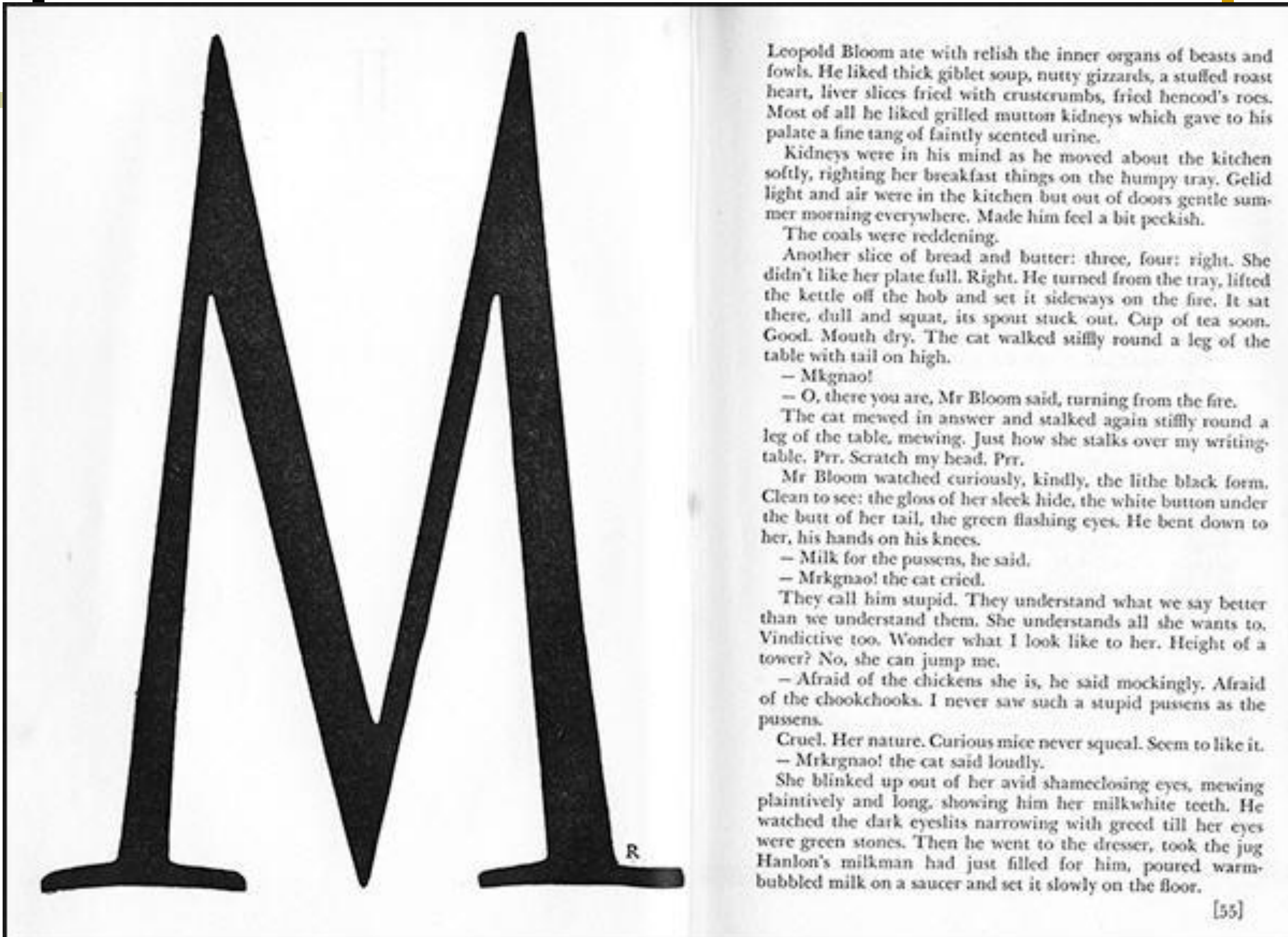
(Dated: August 21, 2012)

2012

This paper presents the complete QED contribution to the electron $g-2$ up to the tenth order. With the help of the automatic code generator, we have evaluated all 12672 diagrams of the tenth-order diagrams and obtained $9.16\,(58)(\alpha/\pi)^5$. We have also improved the eighth-order contribution obtaining $-1.9097\,(20)(\alpha/\pi)^4$, which includes the mass-dependent contributions. These results lead to $a_e(\text{theory}) = 1\,159\,652\,181.78\,(77) \times 10^{-12}$. The improved value of the fine-structure constant $\alpha^{-1} = 137.035\,999\,174\,(35)\,[0.25\text{ppb}]$ is also derived from the theory and measurement of a_e.



Sublime: Ulysses



M

Leopold Bloom ate with relish the inner organs of beasts and fowls. He liked thick giblet soup, nutty gizzards, a stuffed roast heart, liver slices fried with crustcrumbs, fried hencod's roes. Most of all he liked grilled mutton kidneys which gave to his palate a fine tang of faintly scented urine.

Kidneys were in his mind as he moved about the kitchen softly, righting her breakfast things on the humpy tray. Gelid light and air were in the kitchen but out of doors gentle summer morning everywhere. Made him feel a bit peckish.

The coals were reddening.

Another slice of bread and butter: three, four: right. She didn't like her plate full. Right. He turned from the tray, lifted the kettle off the hob and set it sideways on the fire. It sat there, dull and squat, its spout stuck out. Cup of tea soon. Good. Mouth dry. The cat walked stiffly round a leg of the table with tail on high.

– Mkgnao!

– O, there you are, Mr Bloom said, turning from the fire.

The cat mewed in answer and stalked again stiffly round a leg of the table, mewing. Just how she stalks over my writingtable. Prr. Scratch my head. Prr.

Mr Bloom watched curiously, kindly, the lithe black form. Clean to see: the gloss of her sleek hide, the white button under the butt of her tail, the green flashing eyes. He bent down to her, his hands on his knees.

– Milk for the pussens, he said.

– Mrkgnao! the cat cried.

They call him stupid. They understand what we say better than we understand them. She understands all she wants to. Vindictive too. Wonder what I look like to her. Height of a tower? No, she can jump me.

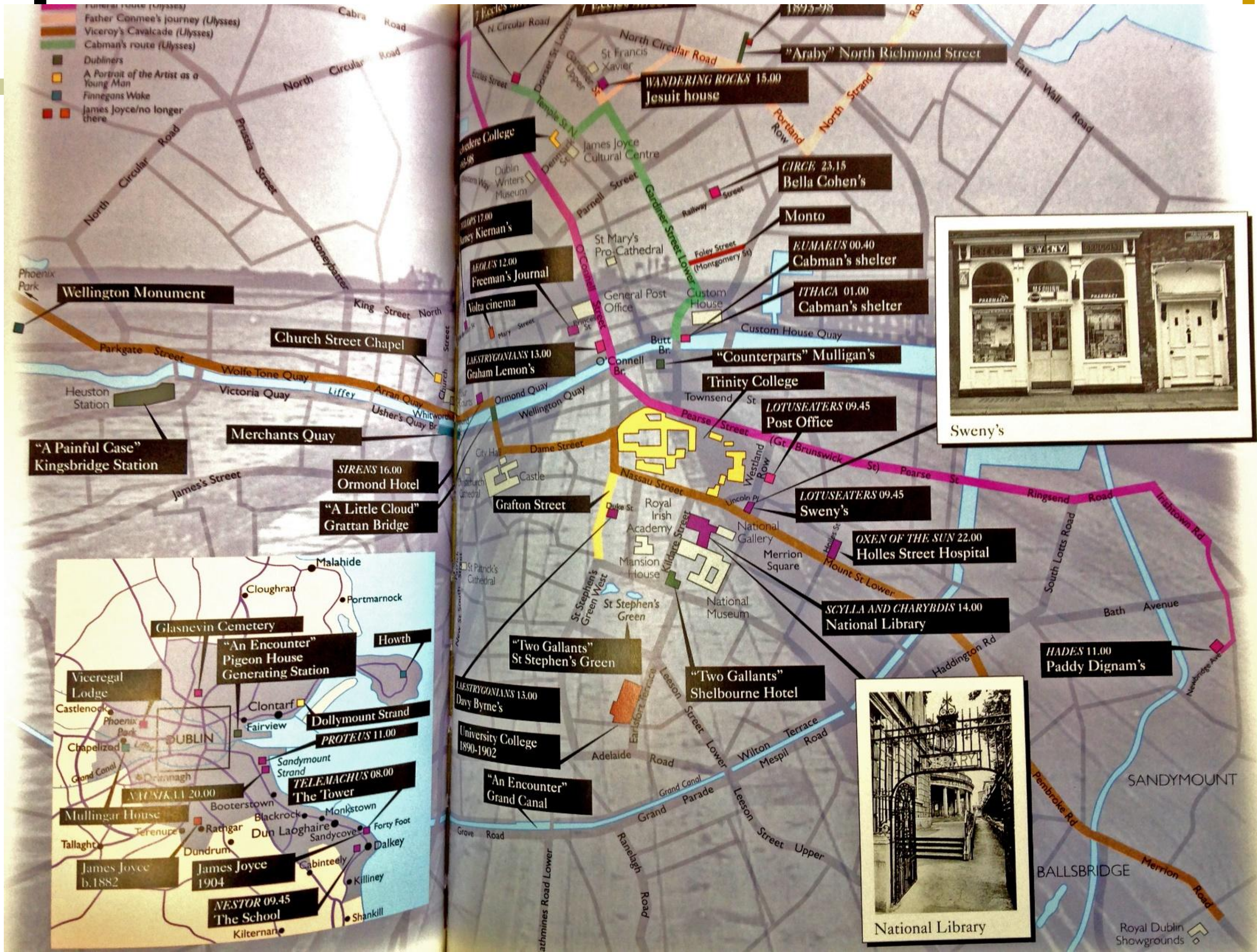
– Afraid of the chickens she is, he said mockingly. Afraid of the chookchooks. I never saw such a stupid pussens as the pussens.

Cruel. Her nature. Curious mice never squeal. Seem to like it.

– Mrkrgnao! the cat said loudly.

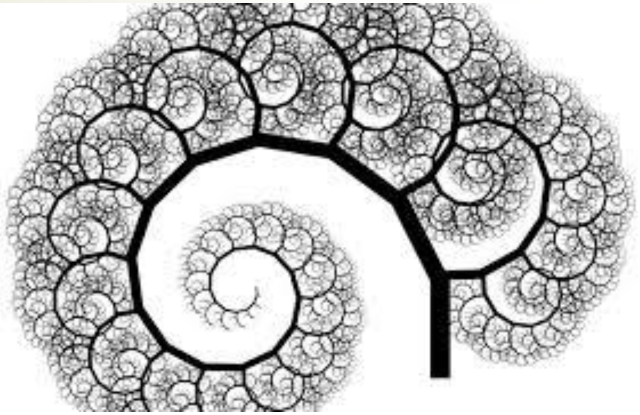
She blinked up out of her avid shameclosing eyes, mewing plaintively and long, showing him her milkwhite teeth. He watched the dark eyeslits narrowing with greed till her eyes were green stones. Then he went to the dresser, took the jug Hanlon's milkman had just filled for him, poured warmbubbled milk on a saucer and set it slowly on the floor.

Bloomsday



Father Conmee's journey (Ulysses)
Viceroy's Cavalcade (Ulysses)
Cabman's route (Ulysses)
Dubliners
A Portrait of the Artist as a Young Man
Finnegans Wake
James Joyce/no longer there
Wellington Monument
Church Street Chapel
"A Painful Case" Kingsbridge Station
Merchants Quay
SIRENS 16.00 Ormond Hotel
"A Little Cloud" Grattan Bridge
Grafton Street
"Araby" North Richmond Street
WANDERING ROCKS 15.00 Jesuit house
CIRCE 23.15 Bella Cohen's
Monto
EUMAEUS 00.40 Cabman's shelter
ITHACA 01.00 Cabman's shelter
AEOLUS 12.00 Freeman's Journal
Volta cinema
LAESTRYGONIANS 13.00 Graham Lemon's
"Counterparts" Mulligan's
Trinity College
LOTUSEATERS 09.45 Post Office
LOTUSEATERS 09.45 Sweny's
OXEN OF THE SUN 22.00 Holles Street Hospital
SCYLLA AND CHARYBDIS 14.00 National Library
HADES 11.00 Paddy Dignam's
"Two Gallants" St Stephen's Green
"Two Gallants" Shelbourne Hotel
LAESTRYGONIANS 13.00 Davy Byrne's
University College 1890-1902
"An Encounter" Grand Canal
Sweny's
National Library
Glasnevin Cemetery
"An Encounter" Pigeon House Generating Station
Howth
Viceregal Lodge
Dollymount Strand
PROTEUS 11.00
TELEMACHUS 08.00 The Tower
NAUSIKAA 20.00
Mullingar House
James Joyce b.1882
James Joyce 1904
NESTOR 09.45 The School
Malahide
Cloughran
Portmarnock
Clontarf
Fairview
DUBLIN
Sandymount Strand
Booterstown
Blackrock
Monkstown
Dun Laoghaire
Sandycove
Forty Foot
Dalkey
Killiney
Shankill
Kilternan
Cabinteely
Dundrum
Rathgar
Terenure
Tallaght
Chapelizod
Castleknock
Phoenix Park
Drimnagh
Grand Canal
North Circular Road
Prussia Street
Stoneybatter
King Street North
Parkgate Street
Wolfe Tone Quay
Victoria Quay
Liffey
Arran Quay
Usher's Quay
Heuston Station
James's Street
Ormond Quay
Wellington Quay
Dame Street
Castle
City Hall
Christchurch Cathedral
St Patrick's Cathedral
O'Connell Street
O'Connell Br.
Butt Br.
Custom House
Custom House Quay
General Post Office
St Mary's Pro-Cathedral
Gardiner Street Lower
Parnell Street
James Joyce Cultural Centre
Dublin Writers Museum
Belvedere College
St Francis Xavier
North Circular Road
Portland Row
North Strand
East Wall Road
Foley Street
Townsend St
Pearse Street
Westland Row
Nassau Street
Lincoln Pl
Royal Irish Academy
Mansion House
Kildare Street
National Gallery
Merrion Square
National Museum
Holles St
Mount St Lower
St Stephen's Green
St Stephen's Green West
Earlsfort Terrace
Leeson Street Lower
Leeson Street Upper
Adelaide Road
Grand Canal
Grand Parade
Wilton Terrace
Mespil Road
Haddington Rd
Bath Avenue
South Lotts Road
Ringsend Road
Irishtown Rd
Newbridge Ave
Pembroke Rd
Merrion Road
SANDYMOUNT
BALLSBRIDGE
Royal Dublin Showgrounds
Grove Road
Ranelagh Road
Rathmines Road Lower

The fabric of reality



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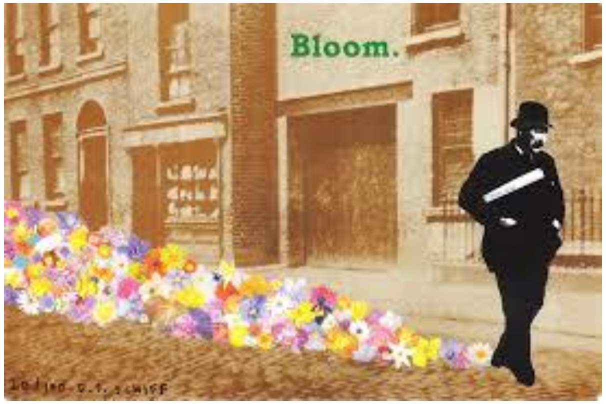

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"A warm human plumpness settled down on his brain. Perfume of embraces all him assailed. With hungered flesh obscurely, he mutely craved to adore."


EXIT
Variance in the stationary process.