

## Reconsidering Maxwell's aether

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(Received 4 February 2014; accepted 6 November 2014; published online 2 December 2014)

**Abstract:** In the 19th century, James Clerk Maxwell developed a theory of aether to explain electromagnetic phenomena. In that era, the existence of aether was generally accepted. In the 20th and 21st centuries, science has moved away from the notion of the existence of aether and into the age of photons and quanta. This article suggests that the scientific community revisit the concept of Maxwell's aether as the fundamental substance that might underlie electromagnetic phenomena. © 2014 Physics Essays Publication. [<http://dx.doi.org/10.4006/0836-1398-27.4.601>]

**Résumé:** Au 19<sup>ième</sup> siècle, James Clerk Maxwell a développé une théorie de l'éther pour expliquer les phénomènes de l'électromagnétisme. Dans cette ère-là, on acceptait généralement l'existence de l'éther. Durant le 20<sup>ième</sup> et le 21<sup>ième</sup> siècle la science a bougé de la notion de l'existence de l'éther et dans l'âge des photons et quanta. Cet article suggère que la communauté scientifique revisite à l'éther de Maxwell comme la substance fondamentale qui pourrait soutenir les phénomènes électromagnétiques.

Key words: Aether; Ether; Electromagnetic Field; Magnetism; Electric Current; Polarization; Induction; Entanglement.

### I. INTRODUCTION

In his paper, entitled *The Dynamical Theory of the Electromagnetic Field*,<sup>1</sup> published in 1865, James Clerk Maxwell set out a theory of aether as a subatomic substance that fills space and occupies all objects. Based upon the assumption that aether exists, he formulated propositions to explain the underlying cause or causes of electromagnetic phenomena. Maxwell's concept of aether met with some success, but the advent of Einstein's special theory of relativity in 1905 and the subsequent development of the quantum theory in effect forced his theory to be abandoned.

This article will attempt to provide arguments for a revisit of Maxwell's theory of aether.

Despite considerable advances in the science of electromagnetism, the underlying behavior of electromagnetic phenomena seems to remain unexplained. Here are some examples. Why is magnetism at right angles to electric current? What physically constitutes magnetism? What is the nature of the constituents of electromagnetic fields? In another parallel area, how can entanglement be explained without resorting to instantaneous action-at-a-distance? Why is a wire that carries an electric current surrounded by a magnetic field? Is the nature of light undulatory or particulate? Why quantum theory cannot be explained with ordinary logic? Can we explain polarization? Dark matter? Dark energy? What is the root cause of quantization?

This is not a complete list, but it illustrates the point that a broad underlying concept might be needed to explain the above phenomena. While present day science describes the practical effects of most of these phenomena, what actually underlies the phenomena remains unexplained. This article

suggests that a return to Maxwell's aether might hold out the prospect of shedding light on those areas of science.

### II. PERCEIVED PROBLEMS WITH QUANTUM THEORY

The expression "quantum theory" in this article is meant to include the various theories based upon the existence of discreteness in nature, or quanta, including quantum mechanics, quantum electrodynamics, and quantum field theory. The majority of scientists consider that quantum theory describes quantum phenomena extremely well. This is not surprising because quantum theory accurately predicts the results of the phenomena under analysis. However, it is well known that underlying explanations are lacking. Consider the following observations from a broad selection of scientists:

David Griffiths, *Introduction to Electrodynamics*:<sup>2</sup>

"I can't tell you, then, what a field is—only how to calculate it and what it can do for you once you have got it." [Emphasis added]

J. D. Jackson, *Classical Electrodynamics*:<sup>3</sup>

"As indicated at the end of the introduction, such idealizations as point charges or electric fields at a point must be viewed as mathematical constructs that permit a description of the phenomena at the macroscopic level, but that may fail to have meaning microscopically." [Emphasis added]

Richard Feynman, *QED: The Strange Theory of Light and Matter*:<sup>4</sup>

"Quantum electrodynamics 'resolves' this wave-particle duality by saying that light is made of particles (as Newton originally thought), but the

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price of this great advancement of science is a retreat by physics to the position of being able to calculate only the probability that a photon will hit a detector, without offering a good model of how it actually happens." [Emphasis added]

Alastair I. M. Rae, *Quantum Mechanics*:<sup>5</sup>

"Defining reality in the context of quantum mechanics is quite a different matter. We have emphasized throughout this book that the wave function is not to be considered as physical, but as a mathematical object from which the possible results of experiments and their relative probabilities can be deduced." [Emphasis added]

Bryan Cox and Jeff Forshaw, *The Quantum Universe*:<sup>6</sup>

"...any explanation of the double-slit experiment requires that the electrons 'interfere with themselves' when they pass through the slits, and to do that they must in some sense be spread out. This therefore is the challenge: build a theory of point-like particles such that those same particles are also spread out. This is not as impossible as it sounds: we can do it if we let any single particle be in many places at once. Of course, that may still sound impossible, but the proposition that a particle should be in many places at once is actually a rather clear statement, even if it sounds silly. From now on, we'll refer to these counterintuitive, spread-out-yet-point-like particles as quantum particles." [Emphasis added]

George Greenstein and Arthur G. Zajonc:<sup>7</sup>

"Take a step backwards now, and survey the above account. Quantum mechanics has correctly reproduced the results of experiment. But has the theory explained to us how indivisible particles manage to pass through two slits at once? It has not." [Emphasis added]

"Quantum theory has therefore succeeded in reproducing the results of experiment. But has it provided us with any understanding of the results? It has not. Indeed, it is quite impossible to visualize what has been going on in these experiments. They present us with an intolerable state of affairs, one which appears to violate the very principles of elementary logic." [Emphasis added]

"On the other hand, at no place did the theory attempt to analyze the particle's path through space. Indeed, as we will discuss in Chapter 3, quantum mechanics regards the very concept of a trajectory as deeply suspect." [Emphasis added]

Patrick Cornille, *Advanced Electromagnetism and Vacuum Physics*:<sup>8</sup>

"A growing minority of physicists working today on the foundations of physics now seems to be

ether-oriented. A new physics of the ether is emerging that in our opinion will much better explain and describe the constitution of matter and radiation. In this book, we will show that Newton's third law is the key for a better understanding of physics. Moreover, the experimental proofs of Newton's third law violations, which are reviewed in this book, demonstrate the existence of what Maxwell termed 'the luminiferous aether.' A serious revision of our understanding of the physical laws governing the universe now seems unavoidable." [Emphasis added]

To summarize, the descriptive nature of quantum theories, as well as their predictive ability, are out of the question. What is missing, however, is the underlying nature of the descriptive tools that it uses. In this article, I will make the attempt by suggesting that Maxwell's aether might provide the underlying nature.

### III. THE EXISTENCE OF AETHER

Ever since the general acceptance of Einstein's special theory of relativity and his expressed view that aether is superfluous, the concept of aether has fallen into general disfavor. David Griffiths puts it this way:<sup>9</sup>

"Special relativity has forced us to abandon the notion of ether, and with it Maxwell's mechanical interpretation of electromagnetic fields."

It is suggested that there is a case to be made for the existence of aether as conceived by Maxwell and for this aether to be playing a fundamental role in electromagnetism.

Aether has a distinguished history. Isaac Newton in his treatise *Opticks* raised the question of whether an elastic substance called "Aether" pervades the "Heavens" and all "Bodies," and by its vibrations is capable of transmitting heat and light. In the words of Newton:<sup>9</sup>

"Is not the Heat of the warm Room convey'd through the Vacuum by the Vibrations of a much subtler Medium than Air, which after the Air was drawn out remained in the Vacuum? And is not this Medium the same with that Medium by which Light is refracted and reflected, and by whose Vibrations Light communicates Heat to Bodies, and is put into Fits of easy Reflexion and easy Transmission? And do not the Vibrations of this Medium in hot Bodies contribute to the intenseness and duration of their Heat? And do not hot Bodies communicate their heat to contiguous cold ones, by the Vibrations of this Medium propagated from them into the cold ones? And is not this Medium exceedingly more rare and subtle than the Air, and exceedingly more elastick and active? And doth it not readily pervade all Bodies? And is it not (by its elastick force) expanded through all the Heavens?"

While Newton ultimately came to the view that light is transmitted by a stream of particles, his contemporary,

Christian Huygens, disagreed with him and maintained that light is a wave.<sup>10</sup> This conflict was resolved in 1801, at least for a century before the advent of the concept of photons, by Dr. Thomas Young's two-slit experiment that demonstrated that light is waves through a medium.<sup>11</sup>

In 1865, Maxwell's *The Dynamical Theory* was published. Maxwell reasoned that an aetherial medium must exist. He described aether as a medium consisting of "parts" and "connections," in which electromagnetic phenomena occur.

The view that aether in fact exists in some form or other is shared by many notable 20th and 21st century scientists, including the following:

Paul Dirac, a Nobel Laureate in physics (1933). In a letter published in NATURE in 1951, entitled *Is there an Aether?*, Dirac opined, with supporting reasons, that a form of aether must exist.<sup>12</sup>

Herbert E. Ives, recipient of the Rumford Medal in 1951 for outstanding contributions to the sciences of heat and light. In his paper entitled *Genesis of the Query "Is there an Aether?"*, published in 1953, Ives set out reasons for the existence of aether.<sup>13</sup>

Maurice Allais, Nobel Laureate in Economics (1988). In his book, *L'Anisotropie de L'Espace*, (1997), he gave detailed reasons why there must be "ether" and argued that that is what present-day scientists call a "field."<sup>14</sup>

Stephen Wolfram, inventor of the computer program, *Mathematica*. In his book entitled *A New Kind of Science*, published in 2002, he describes space as being a "giant network of nodes" or "cells."<sup>15</sup>

Patrick Cornille, author of *Advanced Electromagnetism and Vacuum Physics*, published in 2003, sets out detailed analyses of why "ether" must exist.<sup>8</sup>

Robert B. Laughlin, Nobel Laureate in physics (1998). In his book, *A Different Universe*, published in 2005, Laughlin expresses the view that a form of matter, that he calls "stuff" and "relativistic ether," permeates space.<sup>16</sup>

Reginald Cahill, in his book *Process Physics: From Information Theory to Quantum Space and Matter*, published in 2005, states that a "quantum foam" forms the substructure of space.<sup>17</sup>

Frank Wilczek, a Nobel Laureate in physics (2004). In his book *The Lightness of Being—Mass, Ether, and the Unification of Forces*, published in 2008, he says that space is filled with a substance. He uses the word "Grid" for this substance.<sup>18</sup>

Many scientists consider that the Michelson–Morley experiment in 1887 and subsequent interferometry tests establish that aether does not exist.<sup>19</sup> However, there is also a body of opinion that interferometry tests establish that aether does exist. Cahill, in his book *Process Physics*, goes into considerable detail explaining why the interferometry testing from Michelson–Morley onwards in fact supports the proposition that aether exists.<sup>20</sup> A detailed analysis leading to the same result is set out in Maurice Allais' book *L'Anisotropie de l'Espace*.<sup>15</sup> An analysis of various experiments and publications reasoning that aether flows into all sides of the Earth and that the Earth encounters aether on its orbital path is set out in the present author's article, *Flowing Aether*:

*A Concept*.<sup>21</sup> That article proposes a mechanical concept of gravity based upon aether—the same aether that is posited in the present article.

This article proceeds on the assumption that aether is a real substance that pervades all space and bodies in the universe.

#### IV. POSTULATED NATURE OF AETHER CELLS

It is postulated "ad hoc" that aether consists of tiny non-rigid subatomic cells that have the property of elasticity, the capacity to vibrate, and the ability to attach to and detach from each other. The postulated cells are considered as the same as the parts and connections that comprise Maxwell's aether. The cells are identical in structure.

It is speculated that elasticity enables aether cells to expand and shrink, twist and untwist, and vibrate when they interact with other aether cells and with ordinary matter. It is also speculated that attachment permits aether cells to act as organized groups. Detachment permits the cells to change their positions relative to one another. Collectively, these properties allow propagation of electromagnetic phenomena.

#### V. MAXWELL'S AETHER

Set out below is a brief summary of Maxwell's aether theory. It is drawn mainly from Maxwell's paper, *The Dynamical Theory of the Electromagnetic Field*,<sup>1</sup> published in 1865.

In an earlier paper published in 1861,<sup>22</sup> entitled *On Physical Lines of Force*, Maxwell developed a mechanical approach to aether based upon vortices. Maxwell omitted the vortices approach in his *Dynamical Theory* essay in 1865. The concept of vortices is not used in the present article.

Summary of Maxwell's aether theory:

- As a fundamental proposition, the concept of action-at-a-distance is rejected; rather, there must be a substance through which electromagnetic phenomena occur.<sup>22</sup>
- Electromagnetic fields are composed of matter in motion.<sup>22</sup> The "matter in motion" is an aetherial medium of "small but real density" that fills space and permeates bodies and is capable of transmitting motion.<sup>23,24</sup>
- The medium consists of parts and connections that are capable of "elastic yielding."<sup>24</sup> It can store energy by elastic "displacement" of its parts and from the motion of its parts.<sup>24</sup> The medium also has the capacity to propagate waves.<sup>24</sup>
- Rotation in a magnetic field arises from rotational movement of the aetherial medium.<sup>25</sup>
- Electromotive force causes electric current.<sup>26</sup> Electric current is variations of electric displacement.<sup>27</sup>
- The elasticity of electric displacement causes a backflow of current when the electromotive force is removed.<sup>28</sup>

- Electric current has momentum which it transfers to the surrounding electromagnetic field through its connection to the field; and the transfer of momentum operates in reverse from the electromagnetic field to the current, the direction depending upon the relative levels of energy in the current and in the surrounding electromagnetic field.<sup>29</sup>
- Polarization is a “forced” state of aether that is placed under stress by electromotive force:<sup>30</sup> Polarization disappears when the electromotive force is removed.<sup>31</sup>
- Summary (in Maxwell’s words):<sup>32</sup>

“It appears therefore that certain phenomena in electricity and magnetism lead to the same conclusion as those of optics, namely, that there is an ethereal medium pervading all bodies, and modified only in degree by their presence; that the parts of this medium are capable of being set in motion by electric currents and magnets; that this motion is communicated from one part of the medium to another by forces arising from the connections of those parts; that under the action of these forces there is a certain yielding depending on the elasticity of these connections; and that therefore energy in two different forms may exist in the medium, the one form being the actual energy of motion of its parts, and the other being the potential energy stored up in the connections, in virtue of their elasticity.”

- Conceptual overview (in Maxwell’s words):<sup>32</sup>
- “Thus, then, we are led to the conception of a complicated mechanism capable of a vast variety of motion, but at the same time so connected that the motion of one part depends, according to definite relations, on the motion of other parts, these motions being communicated by forces arising from the relative displacement of the connected parts, in virtue of their elasticity.”

## VI. IMPLICATIONS

The potential implications of returning to Maxwell’s aether might be far reaching. They involve most if not all areas of electromagnetism. The effects of these phenomena are well known to science, but little is known about their underlying cause or causes. If one accepts the concept of Maxwell’s aether, a visualizable, mechanical, and understandable pattern emerges. Phenomena considered here are.

### A. Electric current

What happens when a light switch is activated and a light bulb some distance away is almost instantly illuminated? What constitutes the current that moves at close to the speed of light between the light switch and the light bulb? The assumption of Maxwell’s aether permits an

alternative explanation of electric current to the presently accepted view of moving electrons and ions, the alternative being that electric current is the result of successive collisions of aether cells (Maxwell’s parts of aether) within and along a conductor, propelled by electromotive force. Whereas the existence of electrons and ions has been experimentally proven and their charge and mass precisely measured, and the existence of aether cells and their properties is only postulated, the objective here is to attempt to show that the postulated existence of aether cells leads to a better overall explanation of a large variety of phenomena.

### B. Back surge of electricity

The back surge of electricity immediately after power is turned off, rather than being caused by the rapid annihilation of the magnetic energy stored in the self-inductance of the circuit, as explained today, can be explained by hypothesizing that the mechanical aether cells are compressed by electromotive force and then snap back into their normal shape when the electromotive force is stopped, like rubber balls springing back into their round shape when the compressing force is removed, thus returning the energy stored during compression.

### C. Magnetic field surrounding a conductor

It is speculated that aether cells might bulge and contract both in the direction of a current and at right angles to the electric current and twist when they collide with adjacent aether cells, thus offering a visualization tool for magnetic fields surrounding live conductors.

### D. Polarization

Assuming that individual aether cells are identical, it is postulated that an electromotive force causes them to collectively assemble into patterns oriented in the direction of the electromotive force. This approach to polarization differs from the idea that the electromagnetic field is polarized, and replaces it with polarization being of the medium of aether.

### E. Magnetism

By postulating that aether cells are affected by electromotive force, a new mechanism of the physical cause of magnetism is introduced.

### F. Electromagnetic radiation

Flexible aether cells permit collisions and interactions to spread out in all directions. In this sense, the existence of aether helps in understanding the propagation of electromagnetic waves.

### G. Electromagnetic field

Aether that is activated by mutual collisions and interactions of its cells may be seen as an electromagnetic field. Considering that a field in vacuum is nothing but an

alteration of the vacuum by removing its quality of emptiness and replacing it with physical properties, one might well postulate that the vacuum is filled with aether cells endowed with physical properties.

#### H. Wave lengths of electromagnetic radiation

Assuming that aether cells are elastic structures capable of vibrating in various directions and with different frequencies, and do so collectively with other aether cells, this might offer an explanation for the broad spectrum of frequencies that electromagnetic radiation transports.

#### I. Inertial induction

The transformation of the kinetic energy of ordinary matter into electricity may be explained by the existence of aether. Anything colliding with aether, such as falling water, can transmit some of its kinetic energy to the aether. Likewise, the energy of activated aether cells can be transformed into movement of matter. In simplistic terms, the movement of falling water can be transformed into vibrations and successive collisions of aether cells, and the energy of aether cells can be transformed into electricity to operate a water pump.

#### J. Entanglement

The existence of an aether offers an explanation to the phenomenon known as “entanglement.” When particles are emitted in opposite directions and detectors are located at various positions from the emission source, they record correlated characteristics (such as spin-up and spin-down) of the “arriving” particles. The results seem to evidence instantaneous communication between the detectors, a form of action-at-a-distance that defies logic. The postulated existence of aether removes the difficulty of action-at-a-distance, and the interaction of the aether cells with the particles determines the correlation of the results.

#### K. Einstein–Podolsky–Rosen

The key conclusion of the famous Einstein–Podolsky–Rosen paper, *Can Quantum-Mechanical Description of Physical Reality be Considered Complete*,<sup>33</sup> reads:

“We are thus forced to conclude that the quantum-mechanical description of physical reality given by wave functions is not complete.”

If aether is postulated to be a real substance and a medium for the transport of probability waves, this provides “(probability) wave functions” with physical reality. This might add the physical reality sought by the EPR paper.

#### L. Photo-electric effect and Compton effect

The photo-electric effect and the Compton effect are cited as proof that photons are transmitted from source to destination. Recorded impacts are evidence of the arrival of the sent photons. However, the same effect can be explained by waves traveling through the medium of aether activating aether cells already located at the destination, thus giving the

false impression of the cells actually having traveled there. Similarity with a line of dominoes provides visualization of this phenomenon. The first one is pushed into the second and so on, with the final domino striking whatever is next to it at the destination. Think also of waves from a ship striking the seashore. It is the waves but not the water that travel from the ship to the shore. It is acknowledged that the photo-electric effect and the Compton effect gained acceptance because they were able to provide a quantitative evaluation of the phenomena, whereas the wave analysis did not, but it is suggested that this was due to the lack of consideration of an aether supporting the waves.

#### M. Dark matter

Assuming that space is permeated by aether and that aether is an unknown form of matter, then a connection between aether and dark matter might be established.

#### N. Dark energy

Assuming that aether cells vibrate and interact with each other, space itself must be a repository of energy. This is evidenced by the calculated temperature of space, that being 2.7°K. Aether energy in space may therefore be what is called “dark energy.”

#### O. Interference

Constructive and destructive interference are typical wave phenomena. It is generally believed that wave phenomena require a medium. The existence of an aether might provide such a medium.

#### P. Refraction

Refraction is the change of direction of waves when moving from one medium to another. Presently, vacuum is also considered a medium for electromagnetic waves. However, a physical medium intuitively more acceptable than vacuum might be the aether.

#### Q. Lensing

Lensing occurs where light from a distant galaxy or cluster of galaxies bends as it passes by the sides of an intervening galaxy or cluster of galaxies, resulting in double or triple images when it arrives at the Earth. The postulated existence of aether opens up potential explanation of such bending of light by aether flowing toward the center of the intervening galaxy or cluster of galaxies.

#### R. Wave/particle duality

The wave/particle duality might be explained by the existence of vibrating individual aether cells (particles) transmitting their energy to neighboring cells in the form of waves.

#### S. Quantization

Assuming that aether cells have identical particle structure that permits them to interact with other aether cells and

with atoms and molecules, this offers a potential explanation that the phenomenon of quantization is due to the discreteness of the interaction between aether cells themselves and atoms and molecules.

## VII. SUPPORTING STATEMENTS FROM OTHER SOURCES

It is realized that the suggested ties between the phenomena dealt with in Sec. VI and Maxwellian aether are speculatively qualitative in nature. However, set out below is a limited sampling of supporting statements from various sources.

*Quantization:* Patrick Cornille in his book, *Advanced Electromagnetism and Vacuum Physics*, in the section entitled *Quantization of oscillating waves of the ether*,<sup>34</sup> provides a detailed analysis tying quantization to the aether wave theory. On the assumption that de Broglie waves are in fact “real physical waves” as distinct from mathematical constructs, Cornille reasons that de Broglie waves can be viewed as structured particles that cause quantization. Cornille concludes:<sup>35</sup>

“The similarity of quantization between classical scalar waves and quantum mechanical waves may suggest a new possible interpretation of quantization. Therefore we can explain the quantization concept in physics by noting that the waving vacuum imposes constraints which imply the existence of operators of the form  $d[\ln(A \cdot B)] = 0$  or  $d[\ln(A/B)] = 0$ , which give the quantization of the variable  $A$  with respect to  $B$ , namely,  $A \cdot B = Ct$  or  $A = Ct/B$ .”

*Photo-electric effect and Compton effect:* In addition to explaining quantization, Cornille reasons that experiments in regard to the photo-electric effect and the Compton effect “can be explained from the classical wave point of view.”<sup>36</sup>

*Interference:* Richard Feynman, in his *Lectures on Physics, Vol. III*,<sup>37</sup> compared the mathematics of the phenomenon of interference of electrons with the mathematics of the interference of water waves in one-slit and two-slit experiments. He observed that the mathematics for each is the same. He said:<sup>37</sup>

“Yet, surprisingly enough, the *mathematics* for relating  $P_1$  and  $P_2$  to  $P_{12}$  (the electron experiment) is extremely simple. For  $P_{12}$  is just like the curve  $I_{12}$  of Fig. 1-2 [the water experiment], and *that* was simple. What is going on at the backstop can be described by two complex numbers that we can call  $\phi_1$  and  $\phi_2$  (they are functions of  $x$ , of course). The absolute square of  $\phi_1$  gives the effect with only hole 1 open. That is,  $P_1 = |\phi_1|^2$ . The effect with only hole 2 open is given by  $\phi_2$  in the same way. That is,  $P_2 = |\phi_2|^2$ . And the combined effect of the two holes is just  $P_{12} = |\phi_1 + \phi_2|^2$ . The mathematics is the same as that we had for the water waves!” (It is hard to see how one could get such a simple result from a complicated game of electrons

going back and forth through the plate on some strange trajectory). [Emphasis added]

*Dark energy and dark matter:* Roberto Monti provides detailed reasoning based upon experimental evidence that: (1) Cosmic microwave background (CMB) in space emanates from aether, and (2) electric conductivity in space is consistent with Maxwell’s aether and inconsistent with Einstein’s traveling quanta. Monti’s reasoning supports the proposition that aether is a repository of energy—viz., its 2.7°K temperature—and is the “blackbody” (dark matter) constituted by the aether.<sup>38</sup>

## VIII. CONCLUSION

The aim of this article is to stimulate work in a fascinating field of science that is notably insufficiently explored—the existence of an aether endowed with physical properties. While this article does not claim that the expressed ideas are proven, it seems that in so many instances Maxwell’s aether appears to provide initial speculative explanations. Although Maxwell’s authority has not caused his aether ideas to prevail at this time, it should be kept in mind that the knowledge available to him in his day was extremely limited in the infant science of electromagnetism. Today, the vacuum is not considered “empty.” It has physical properties. It is suggested that the aether envisaged by Maxwell might fill such vacuum.

## ACKNOWLEDGMENTS

I am grateful to Keith Liddle for his constructive suggestions during the preparation of this paper.

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