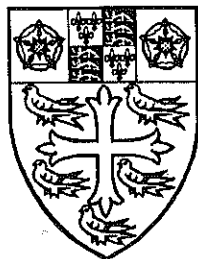


Westminster Abbey



5.00 p.m. Evensong

6.00 p.m. Dedication of a Memorial
to Paul Adrien Maurice Dirac, OM
Theoretical Physicist

$$i\partial\psi/\partial t = \{ip_1(\sigma \cdot \nabla) + \rho_3 m\}\psi$$

P. A. M. Dirac

Monday 13 November 1995



Paul Adrien Maurice Dirac

Paul Adrien Maurice Dirac was born in Bristol on 8 August 1902, the second son of Charles Dirac, a Swiss national, and Florence Holten, of Cornish birth. Paul's primary and secondary education was at the Merchant Venturers Technical College in Bristol, where his father was French master.

In 1918, Paul became a student of electrical engineering at the University of Bristol, living at home with family support. He graduated first-class in 1921. St John's College, Cambridge, offered him a small scholarship, amounting to one-third of the total needed, but he could not accept it since his family had no available supplementary funds. Instead, he became an unofficial student of mathematics at Bristol University, paying no fees and living at home. In 1923 he was awarded a DISR studentship for postgraduate research at Cambridge, but this covered only two-thirds of the total needed. Dirac then asked St John's College whether they might grant him the scholarship that he had not been able to accept from them in 1921. Though he had no right to it, the college did agree to give it to him. With this modest investment, the college secured a man who was soon to enhance greatly its academic reputation. Dirac spent the rest of his life until his retirement at St John's, becoming an 1851 Exhibition Student in 1925, a fellow in 1927, and the Lucasian Professor of Mathematics of the university in 1932. Without this supplement in 1923, Dirac could not have become a research student at Cambridge. Lacking the scientific contacts available there, he could have taken no part in the development of the New Quantum Mechanics.

By the end of 1925 he had begun to make his name known internationally. Having a chance opportunity to read a proof copy of Heisenberg's first paper on the New Quantum Mechanics, he gave his own interpretation of an unfamiliar mathematical expression that arose in it, and from this developed his concept of 'q' numbers and his own version of quantum theory – more general than those of Heisenberg and Schrodinger. These achievements gained him a place at the 1927 Solvay Congress at Brussels, where at the age of 25 he met the leading physicists, such as Einstein, Lorentz and others.

At the end of 1928 Dirac found his relativistic equation for the electron, the goal of all theoretical physicists of that time. It had remarkable successes, predicting spin 1/2 for the electron, as observed; an intrinsic magnetic moment, as measured; and giving an excellent account of the spectrum of the hydrogen atom. It also uncovered a serious difficulty that took several years to understand: that is, states of negative energy for the electron. In 1931, Dirac interpreted these as positive energy states of the anti-electron, a particle having the same mass as the electron but an opposite charge. This particle, known as the positron, was found in the cosmic radiation in 1932. With these remarkable successes behind him, Dirac was awarded, jointly with Schrodinger, the 1933 Nobel Prize for Physics.

Dirac went on to establish the foundations of quantum field theory, using it for the discussion of many physical processes, and to put forward his Large Numbers Hypothesis, drawing cosmological consequences from it. More recently, in the 1950s and '60s, he did significant research bearing on the theory of gauge fields, which are so important in physics today. Dirac retired from his professorship at Cambridge in 1969 and accepted a permanent research professorship at Florida State University at Tallahassee - where he died on 20 October 1984, and where he is buried.

We welcome you to this service. Worship has been offered to God daily on this site for over a thousand years. Today, you are a member of a congregation which comes from all over the British Isles and from all over the world. Though we may not know each other, we are fellow members of the world-wide Church.

Evensong is the distinctive service of Evening Prayer used by churches of the Anglican Communion, and is held daily in the Abbey. It includes elements from the medieval Latin offices of Vespers and Compline, and has been largely unchanged since the first English Prayer Book of 1549.

As is customary in churches with a great choral tradition, much of the service is sung by the Choir alone, and the congregation makes its offering of praise by responding to the beauty of the Choir's music.

Users of hearing aids are invited to ask the Vergers to direct them to the North Lantern area, where a Hearing Aid Loop is installed. The hearing aid should be adjusted to the setting T.

It is our custom to keep a period of silence and reflection to prepare ourselves for the service.

The Service is sung by the Junior Choristers and Lay Vicars of Westminster Abbey, conducted by Martin Neary, Organist and Master of the Choristers.

The Organ is played by Stephen le Prevost, Assistant Organist of Westminster Abbey.

Music before the Service:

In paradisum

Henri Mulet (1878–1967)

The Order of Evensong

All stand for the Procession of Visiting Representatives to enter the Quire, and then sit.

PRESIDENT OF THE
ROYAL SOCIETY
Sir Micahel Atiyah

PAST PRESIDENT OF THE
ROYAL SOCIETY
The Lord Porter

PRESIDENT OF THE
INSTITUTE OF PHYSICS
Sir Arnold Wolfendale

MASTER OF ST JOHN'S COLLEGE
UNIVERSITY OF CAMBRIDGE
Professor Peter Goddard

Professor Abraham Pais

Professor David Olive

Professor Roger J Blin-Stoyle

VICE CHANCELLOR
UNIVERSITY OF BRISTOL
Sir John Kingman

THE LUCASIAN PROFESSOR
CAMBRIDGE UNIVERSITY
Professor Stephen Hawking

PRESIDENT OF THE LONDON
MATHEMATICAL SOCIETY
Professor Nigel Hitchin

CHIEF SECRETARY
HER MAJESTY'S TREASURY
*The Right Honourable
William Waldegrave MP*

PRESIDENT AND DEAN
ST JOHN'S COLLEGE
UNIVERSITY OF CAMBRIDGE
The Reverend Andrew Macintosh

Professor Maurice Jacob

Professor John C Taylor

Professor Richard H Dalitz

HEAD OF APPLIED MATHEMATICS
AND THEORETICAL PHYSICS
University of Cambridge
Professor David Crighton

All remain seated. The Choir sings THE INTROIT in the Nave:

Drop, drop, slow tears,
and bathe those beauteous feet,
which brought from heaven
the news and Prince of peace.

Cease not, wet eyes,
his mercies to entreat;
to cry for vengeance
sin doth never cease.

In your deep floods
drown all my faults and fears;
nor let his eye
see sin, but through my tears.

*Song 46
Orlando Gibbons (1583-1625)
Organist of Westminster Abbey 1623-25*

Phineas Fletcher (1582-1650)

All stand as the Procession of the Collegiate Body enters the Quire.

VERSICLES AND RESPONSES

Thomas Tomkins (1573–1656)

O Lord, open thou our lips;
And our mouth shall shew forth thy praise.

O God, make speed to save us;
O Lord, make haste to help us.

Glory be to the Father, and to the Son: and to the Holy Ghost;
As it was in the beginning, is now, and ever shall be: world without end. Amen.

Praise ye the Lord.
The Lord's name be praised.

All sit. The Choir sings PSALM 69: 1–9:

Save me, O God: for the waters are come in, even unto my soul.
I stick fast in the deep mire, where no ground is: I am come into deep waters, so that
the floods run over me.
I am weary of crying; my throat is dry: my sight faileth me for waiting so long upon
my God.
They that hate me without a cause are more than the hairs of my head: they that are
mine enemies, and would destroy me guiltless, are mighty.
I paid them the things that I never took: God, thou knowest my simpleness, and my
faults are not hid from thee.
Let not them that trust in thee, O Lord God of hosts, be ashamed for my cause: let not
those that seek thee be confounded through me, O Lord God of Israel.
And why? for thy sake have I suffered reproof: shame hath covered my face.
I am become a stranger unto my brethren: even an alien unto my mother's children.
For the zeal of thine house hath even eaten me: and the rebukes of them that rebuked
thee are fallen upon me.

All stand.

Glory be to the Father, and to the Son: and to the Holy Ghost;
As it was in the beginning, is now, and ever shall be: world without end. Amen.

*All sit. The Reverend Dr Donald Gray, Canon in Residence, reads THE FIRST LESSON:
Daniel 9: 1-3, 20–end*

*All stand. The Choir sings MAGNIFICAT to the setting in B minor by T Tertius Noble
(1867–1953):*

My soul doth magnify the Lord: and my spirit hath rejoiced in God my Saviour.
For he hath regarded: the lowliness of his hand-maiden.
For behold, from henceforth: all generations shall call me blessed.
For he that is mighty hath magnified me: and holy is his Name.

And his mercy is on them that fear him: throughout all generations.
He hath shewed strength with his arm: he hath scattered the proud in the imagination of their hearts.
He hath put down the mighty from their seat: and hath exalted the humble and meek.
He hath filled the hungry with good things: and the rich he hath sent empty away.
He remembering his mercy hath holpen his servant Israel: as he promised to our forefathers, Abraham and his seed for ever.
Glory be to the Father, and to the Son: and to the Holy Ghost;
As it was in the beginning, is now, and ever shall be: world without end. Amen.

All sit. The Canon in Residence reads THE SECOND LESSON:
St Mark 9: 2-13

All stand. The Choir sings NUNC DIMITTIS *to the setting to the setting in B minor by Tertius Noble:*

Lord, now lettest thou thy servant depart in peace: according to thy word.
For mine eyes have seen: thy salvation;
Which thou hast prepared: before the face of all people;
To be a light to lighten the Gentiles: and to be the glory of thy people Israel.
Glory be to the Father, and to the Son: and to the Holy Ghost;
As it was in the beginning, is now, and ever shall be: world without end. Amen.

All face the High Altar and say together THE APOSTLES' CREED:

I believe in God the Father Almighty, Maker of heaven and earth: and in Jesus Christ his only Son our Lord, who was conceived by the Holy Ghost, born of the Virgin Mary, suffered under Pontius Pilate, was crucified, dead, and buried; he descended into hell; the third day he rose again from the dead, he ascended into heaven, and sitteth on the right hand of God the Father Almighty; from thence he shall come to judge the quick and the dead.

I believe in the Holy Ghost; the holy catholic Church; the communion of saints; the forgiveness of sins; the resurrection of the body; and the life everlasting. Amen.

The Lord be with you; And with thy spirit.

All kneel or sit.

Let us pray.

Lord, have mercy upon us. Christ, have mercy upon us. Lord, have mercy upon us.

THE LORD'S PRAYER

O Lord, shew thy mercy upon us;
And grant us thy salvation.

O Lord, save the Queen;
And mercifully hear us when we call upon thee.

Endue thy ministers with righteousness;
And make thy chosen people joyful.

O Lord, save thy people;
And bless thine inheritance.

Give peace in our time, O Lord;
Because there is none other that fighteth for us, but only thou, O God.

O God, make clean our hearts within us;
And take not thy Holy Spirit from us.

THE COLLECTS

THE PRAYERS FOR THE ROYAL FAMILY AND FOR THE ORDER OF THE BATH.

All sit. The Choir sings THE ANTHEM:

Oculi omnium in te sperant Domine:
et tu das escam illorum in tempore
opportuno.

Gloria tibi Domine. Amen.

Charles Wood (1866-1926)

*The eyes of all wait upon thee, O Lord:
and thou givest them their meat in due
season.*

Glory be to thee, O Lord. Amen.

Psalm 145: 15

All kneel or sit for THE INTERCESSIONS.

At the end of the Intercessions, all say together:

The grace of our Lord Jesus Christ, and the love of God and the fellowship of the Holy Spirit, be with us all evermore. Amen.

All stand as the Procession of the Collegiate Body leaves the Quire.

Members of the Congregation who do not wish to attend the Dedication of the memorial may leave at this point as directed by the Honorary Stewards.

Those who do wish to attend the Dedication are requested to move at the direction of the Honorary Stewards and be seated in the Nave.

Between Evensong and the Dedication, Martin Baker, Sub-Organist of Westminster Abbey, plays:

Chorale prelude:
Allein Gott in der Höh sei Ehr, BWV663

Johann Sebastian Bach (1685-1750)

The Order of the Dedication

All stand as the Procession of the Collegiate Body enters the Nave, and then sit.

The Canon in Residence gives THE INTRODUCTION.

All remain seated for

A SERIES OF READINGS

illustrating the remarkable and unusual human qualities of Dirac

Sir Arnold Wolfendale, President of the Institute of Physics, and Emeritus Professor of Physics, University of Durham, reads:

[The 'Dirac Equation'] seemed and still seems to me the most beautiful and exciting piece of pure theoretical physics that I have seen in my lifetime: comparable with Maxwell's deduction that the displacement current, and, therefore, electromagnetic waves must exist. I was immensely impressed, as were the few senior people in Cambridge who were competent to judge such things.

Nevill Mott in *Paul Adrien Maurice Dirac*, ed. B Kursunoglu and E Wigner (Cambridge, 1986), p.231

[Dirac] would never compromise his principles and would stick absolutely to what he saw as right. No doubt the best comment on him was the remark by Niels Bohr, 'Of all physicists, Dirac has the purest soul.'

Rudolf Peierls in *Tributes to Paul Dirac*, ed. J G Taylor (Bristol, 1987), p.37

Dirac worked as if in a dream, holding a soliloquy with rows of symbols chalked on the board. Even when others were present, he hardly ever used words. Even the initiated could not always follow his mental processes.

George Gamow (1966)

Dirac's unique intellect was evident in everything he wrote. Rudolf Peierls suggested that it was Dirac's absolutely straight thinking in unexpected ways that made his work so characteristic. He did not follow conventions but rather thought everything out from first principles. Bohr said that he had the most remarkable scientific mind since Newton.

Peter Goddard in *The Eagle* [St John's Cambridge Magazine], lxxi/294 (1986), p.69-77

I still remember how much I learned from his book, that great classic on quantum mechanics. There is purity of style in his work which goes directly to the heart of the subject.

Dirac's papers have a distinctive style which is unique. I would characterize this unique style by the words purity, elegance, cogency, and restraint.

One finds in his papers an economy of words. It is as if in writing them down he was carefully sculpturing a condensation of thought and of logic.

Chen-Ning Yang (1984)

All remain seated. *The Sub-Organist plays:*

Chorale prelude:
Liebster Jesu, wir sind hier, BWV730

Johann Sebastian Bach

All remain seated for

READINGS

illustrating Dirac's rapid rise and his later philosophical attitudes

Professor Peter Goddard, Master of St John's College and Professor of Mathematics, University of Cambridge, reads:

A passage from J H Jeans' report to the Commissioner of the 1851 Exhibition commemorative studentships on Dirac's tenure of his Senior Studentship for the period 1925-8:

'During the last three years Mr Dirac has shown himself to be in the very foremost rank of the Applied Mathematicians, not only of this country but of the whole world. The whole of his work has been of outstanding importance, especially his last two papers on the quantum theory of the electron.'

A passage from Dirac himself, writing in the *Scientific American* of May 1963:

It seems to be one of the fundamental features of nature that fundamental physical laws are described in terms of a mathematical theory of great beauty and power, needing quite a high standard of mathematics for one to understand it. You may wonder: Why is nature constructed along these lines? One can only answer that our present knowledge seems to show that nature is so constructed. We simply have to accept it. One could perhaps describe the situation by saying that God is a mathematician of a very high order, and He used very advanced mathematics in constructing the universe. Our feeble attempts at mathematics enable us to understand a bit of the universe, and as we proceed to develop higher and higher mathematics we can hope to understand the universe better. [p.53]

And later in the same piece:

If someone can hit on the right lines along which to make this development, it may lead to a future advance in which people will first discover the equations and then, after examining them, gradually learn how to apply them. To some extent that corresponds with the line of development that occurred with Schrodinger's discovery of his wave equation. Schrodinger discovered the equation simply by looking for an equation with mathematical beauty. When the equation was first discovered, people saw that it fitted in certain ways, but the principles according to which one should apply it were worked out only some two or three years later. It may well be that the next advance in physics will

come about along these lines: people first discovering the equations and then needing a few years of development in order to find the physical ideas behind the equations. My own belief is that this is a more likely line of progress than trying to guess at physical pictures. [*ibid*]

All remain seated. The Canon in Residence invites Sir Michael Atiyah, President of the Royal Society, to unveil the Memorial.

Sir Michael Atiyah says:

Reverend Sir, I ask you to receive into the safe custody of the Dean and Chapter, here in the Nave of the Abbey among the memorials of other scientists, this memorial honouring the theoretical physicist Paul Dirac.

All stand. The Canon in Residence says:

To the greater glory of God and in thankful memory of Paul Dirac we dedicate this memorial: in the name of the Father, and of the Son, and of the Holy Spirit.

*All say: **Amen.***

All sit for

THE ADDRESS
given by
Professor Stephen Hawking, CH, CBE
*Lucasian Professor of Mathematics,
University of Cambridge*

All stand. The Reverend Barry Fenton, Precentor of Westminster Abbey, says:

Let us give thanks to God
for the beauty, complexity and mystery of all created things, and for his gift to human
beings of the capacity for inquiry, analysis and wonder;
for the understanding and insight that he has given to all mathematicians and scientists,
among whom we remember particularly Paul Dirac.

*All say: **Lord, in your mercy, hear our prayer.***

Let us offer prayer
for those who in our own time are involved in the continuing work of research,
consideration and discovery;
for academic institutions and learned societies committed to the exploration and
application of discoveries in the material world;
and for ourselves and all people, that we may be faithful stewards of the powers of
wisdom and knowledge with which God has entrusted us, and that we may use such
understanding for our good and the good of each other.

All say: **Lord, in your mercy, hear our prayer.**

O God, who from your bountiful liberality have poured upon mankind a great variety
of gifts, sweetly and gently ordering them by the operation of your free Spirit, guide us
each to desire your perfection, to seek for your truth, and to rejoice in your beauty:
that in the discovery of your manifold works we may come to know you, the only God,
through him from whom all things have their origin, even Jesus Christ the Lord.
Amen.

*The Reverend Andrew Macintosh, President of St John's College, University of
Cambridge, continues:*

Bless, O Lord, the work of the College of St John the Evangelist in the University of
Cambridge; and grant that love of the bretheren and all sound learning may ever grow
and prosper therein; to thy honour and glory and to the good of thy people; who livest
and reignest with the Father and the Holy Spirit, one God, world without end. **Amen.**

Almighty God, who hast created man in thine own image, and made him a living soul
that he might seek after thee and have dominion over thy creatures, teach us to study the
works of thy hands and strengthen our reason for thy service; and so to receive thy
blessed word that we may believe on him whom thou hast sent to give us the knowledge
of salvation and the remission of our sins. All which we ask in the name of the same
Jesus Christ our Lord. **Amen.**

James Clerk Maxwell (1831-79)

All sit.

Flowers are laid on the Memorial plaque by representatives of the Dirac family:

Dr Monica Dirac, daughter;
Mr Paul Parker, grandson;
and Miss Victoria Dirac, granddaughter

All stand to sing THE HYMN:

Lord of beauty, thine the splendour
shewn in earth and sky and sea,
burning sun and moonlight tender,
hill and river, flower and tree:
lest we fail our praise to render
touch our eyes that they may see.

Lord of wisdom, whom obeying
mighty waters ebb and flow,
while unhasting, undelaying,
planets on their courses go:
in thy laws thyself displaying,
teach our minds thyself to know.

Regent Square 106 (t 185) AMNS
Henry Smart (1813-79)

Lord of life, alone sustaining
all below and all above,
Lord of love, by whose ordaining
sun and stars sublimely move:
in our earthly spirits reigning,
lift our hearts that we may love.

Lord of beauty, bid us own thee,
Lord of truth, our footsteps guide,
till as Love our hearts enthrone thee,
and, with vision purified,
Lord of all, when all have known thee,
thou in all art glorified.

C A Alington (1872-1955)

All remain standing. The Canon in Residence says THE BLESSING. *All say: Amen.*

The Processions move to the west end of the church.

After the Dedication the Sub-Organist plays:

Prelude and Fugue in A major, BWV536

Johann Sebastian Bach

Members of the Congregation are invited to view the Memorial as indicated by the Honorary Stewards.