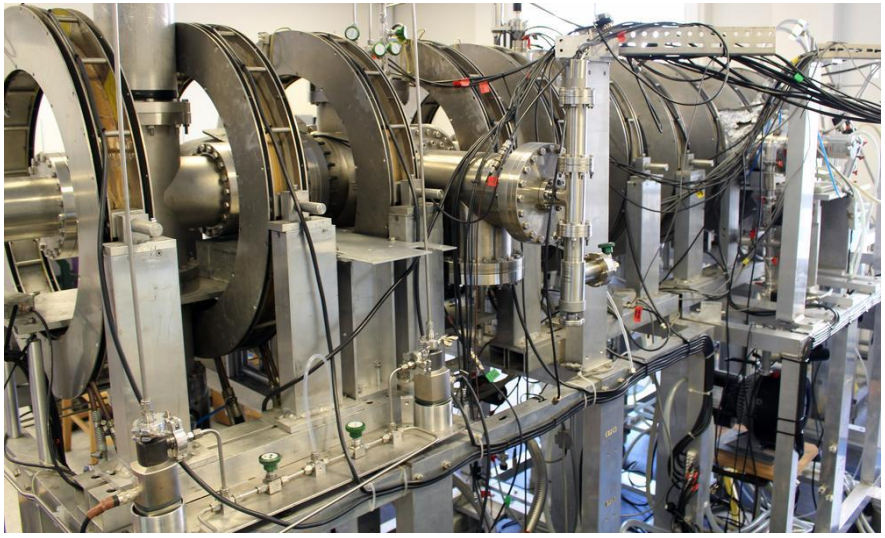
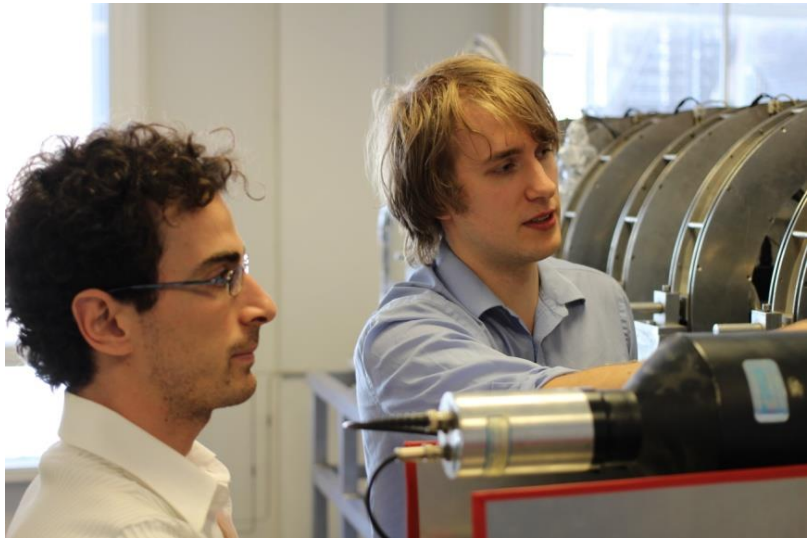
Collisions involving antimatter





Gaetana Laricchia

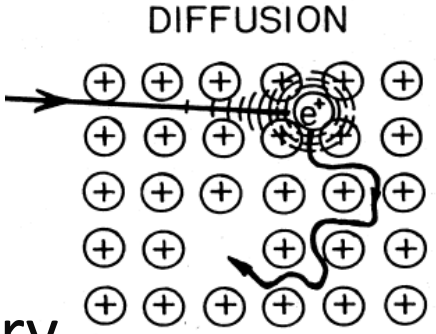
UCL Department of Physics and Astronomy , University College London

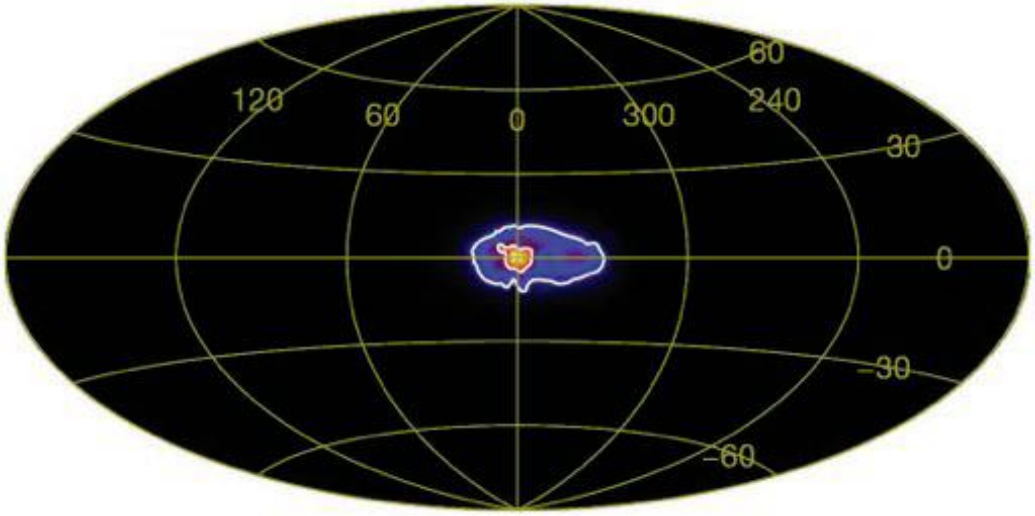
London WC1E 6BT, United Kingdom

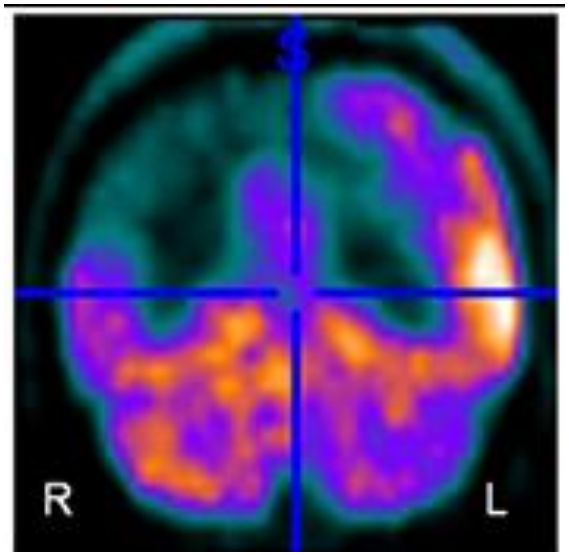
Please contact: g.laricchia@ucl.ac.uk

Why do (e^+, Ps) collisions (with matter) matter?

- Matter-antimatter interactions
- Material properties
- Medical imaging (PET) and nanodosimetry
- Astrophysical and atmospheric events







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10 November 2016

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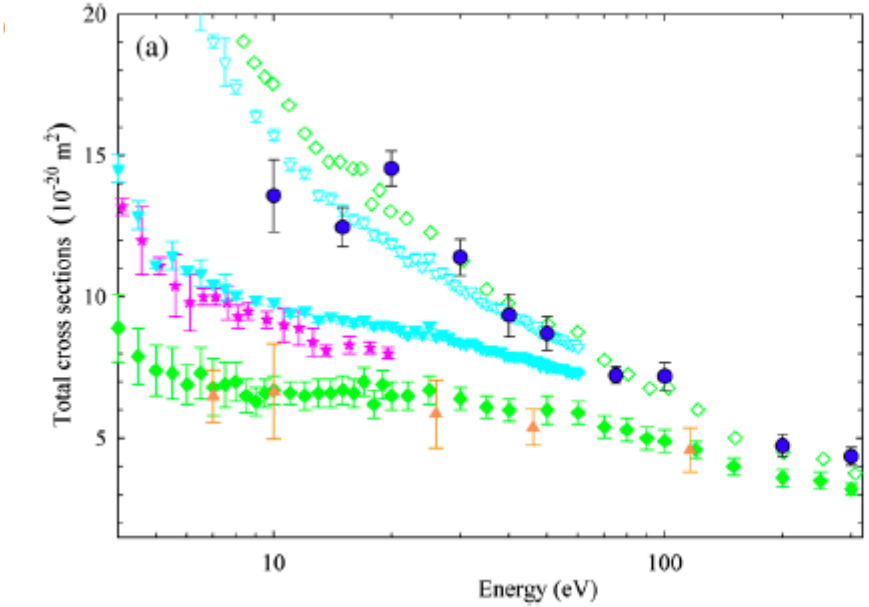
DECEMBER 2016

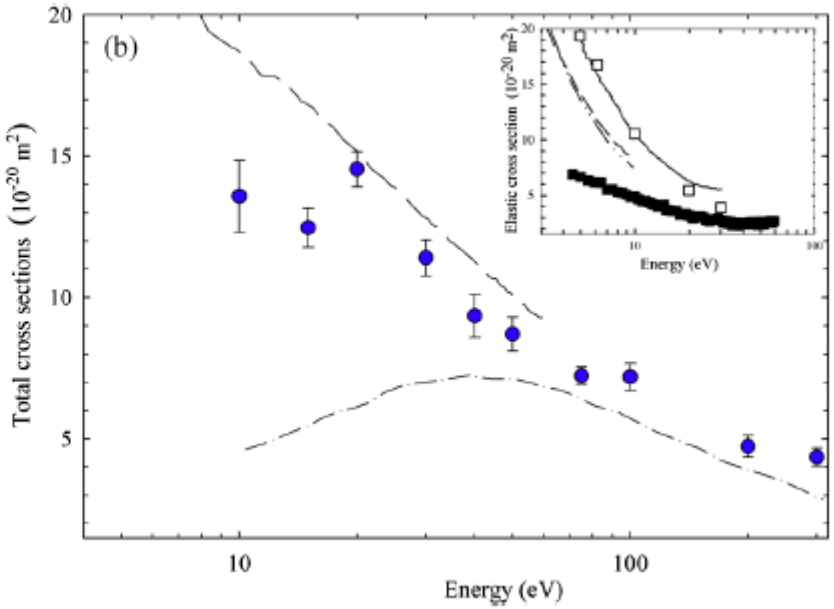
High-Resolution Measurements of $e^+ + H_2O$ Total Cross Section

A. Loreti,[1] R. Kadokura,[1] S. E. Fayer,[1] Á. Kövér,[2] and G. Laricchia[1,*]

[1]*UCL Department of Physics and Astronomyy, University College London, Gower Street, London, WC1E 6BT, United Kingdom*
[2]*Institute for Nuclear Research of Hungarian Academy of Science, Debrecen, PO Box 51, H-4001, Hungary*

Using a purely electrostatic positron beam, the total cross section of positrons scattering from H_2O has been measured for the first time with a high angular discrimination ($\simeq 1°$) against forward scattered projectiles. Results are presented in the energy range (10–300) eV. Significant deviations from previous measurements are found which are, if ascribed entirely to the angular acceptances of various experimental systems, in quantitative accord with *ab initio* theoretical predictions of the differential elastic scattering

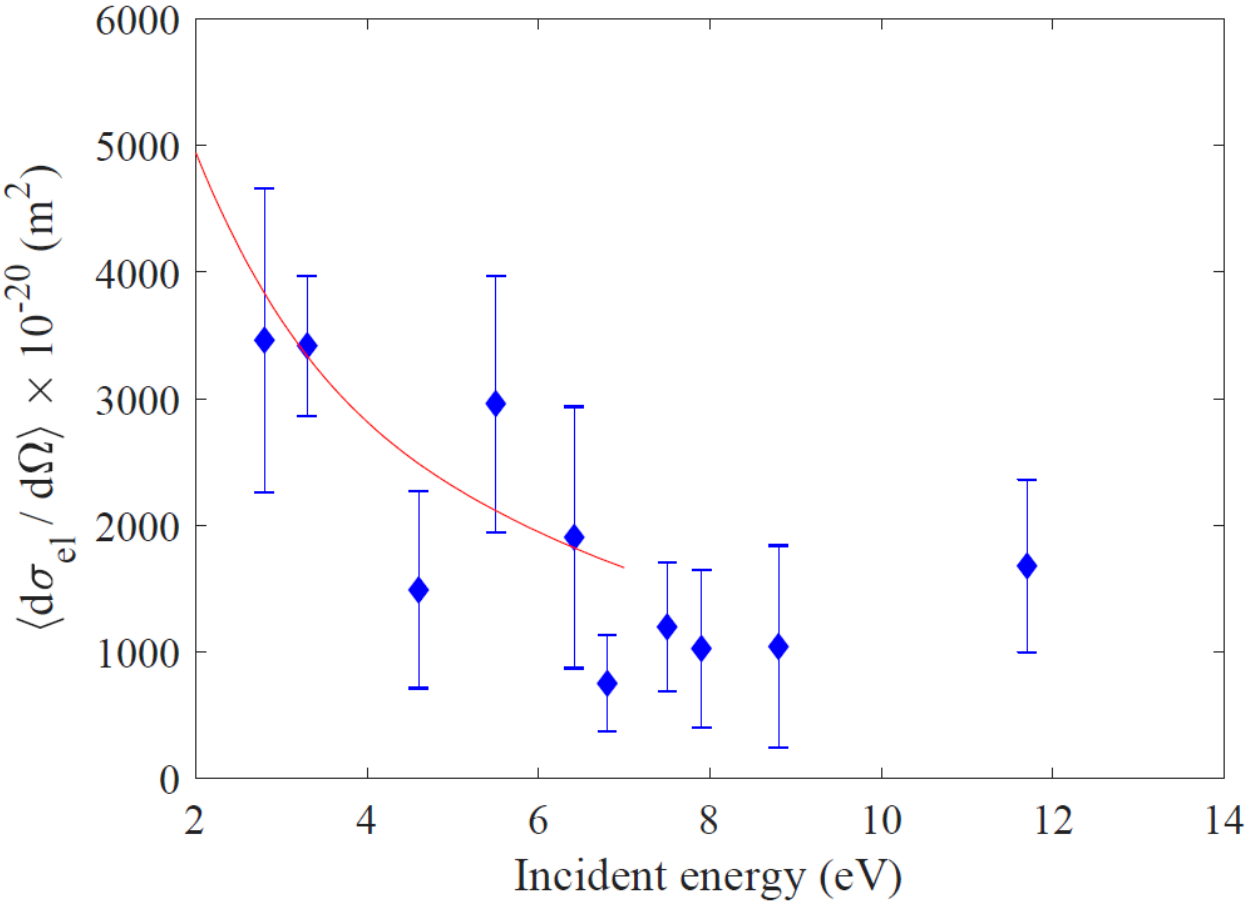




PHYSICAL REVIEW LETTERS **123,** 033401 (2019)

Angle-Resolved Electron Scattering from H_2O near 0°

R. Kadokura,[1] A. Loreti,[1] Á. Kövér,[2] A. Faure,[3] J. Tennyson,[1] and G. Laricchia[1]
[1]*UCL Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, United Kingdom*
[2]*MTA Institute for Nuclear Research (Atomki), Bem ter 18/c, H-4026 Debrecen, Hungary*
[3]*Université Grenoble Alpes, 621 avenue Centrale, 38400 Saint-Martin-d'Hères, France*

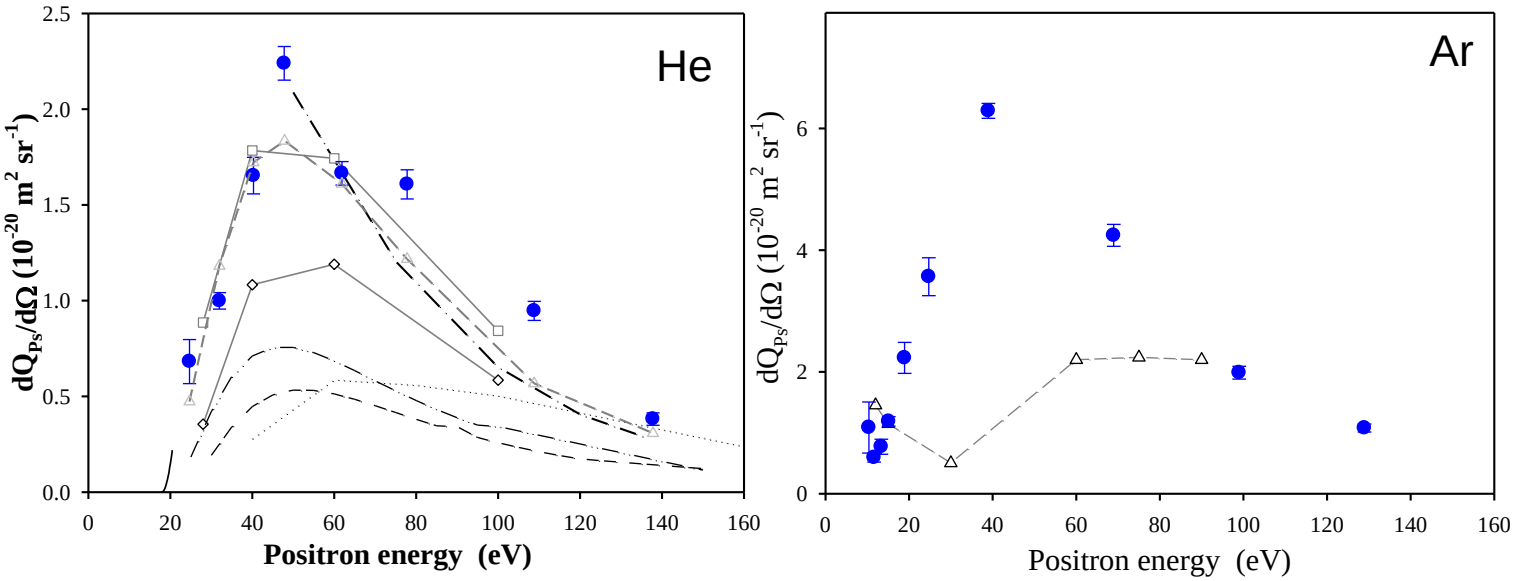


PRL 115, 033401 (2015) PHYSICAL REVIEW LETTERS week ending 17 JULY 2015

Absolute Differential Positronium-Formation Cross Sections

M. Shipman, S. Armitage, J. Beale,[†] S. J. Brawley, S. E. Fayer, A. J. Garner, D. E. Leslie,[‡] P. Van Reeth, and G. Laricchia[*]
UCL Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, United Kingdom
(Received 15 April 2015; published 14 July 2015)

The first absolute experimental determinations of the differential cross sections for the formation of ground-state positronium are presented for He, Ar, H_2, and CO_2 near 0°. Results are compared with available theories. The ratio of the differential and integrated cross sections for the targets exposes the higher propensity for forward emission of positronium formed from He and H_2.



PHYSICAL REVIEW A **100**, 062709 (2019)

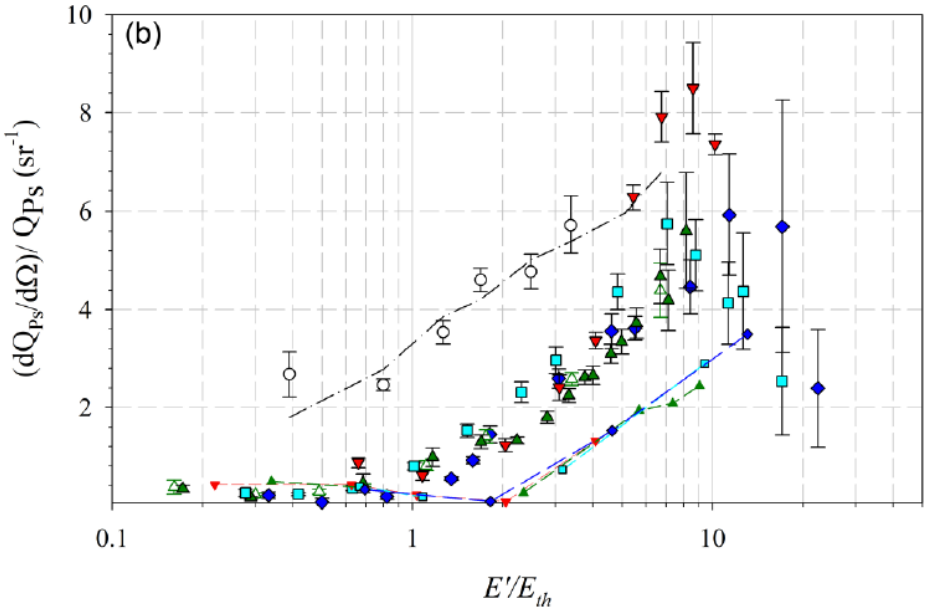
Differential positronium-formation cross sections for Ne, Ar, Kr, and Xe

S. E. Fayer,[1,*] D. M. Newson,[1] S. J. Brawley,[1] A. Loreti,[1] R. Kadokura,[1] T. J. Babij,[2] J. Lis,[1,†] M. Shipman,[1] and G. Laricchia[1,‡]

[1]*UCL Department of Physics and Astronomy, University College London, Gower Street, London, WC1E 6BT, United Kingdom*
[2]*Research School of Physics and Engineering, Australian National University, Canberra, ACT 2600, Australia*

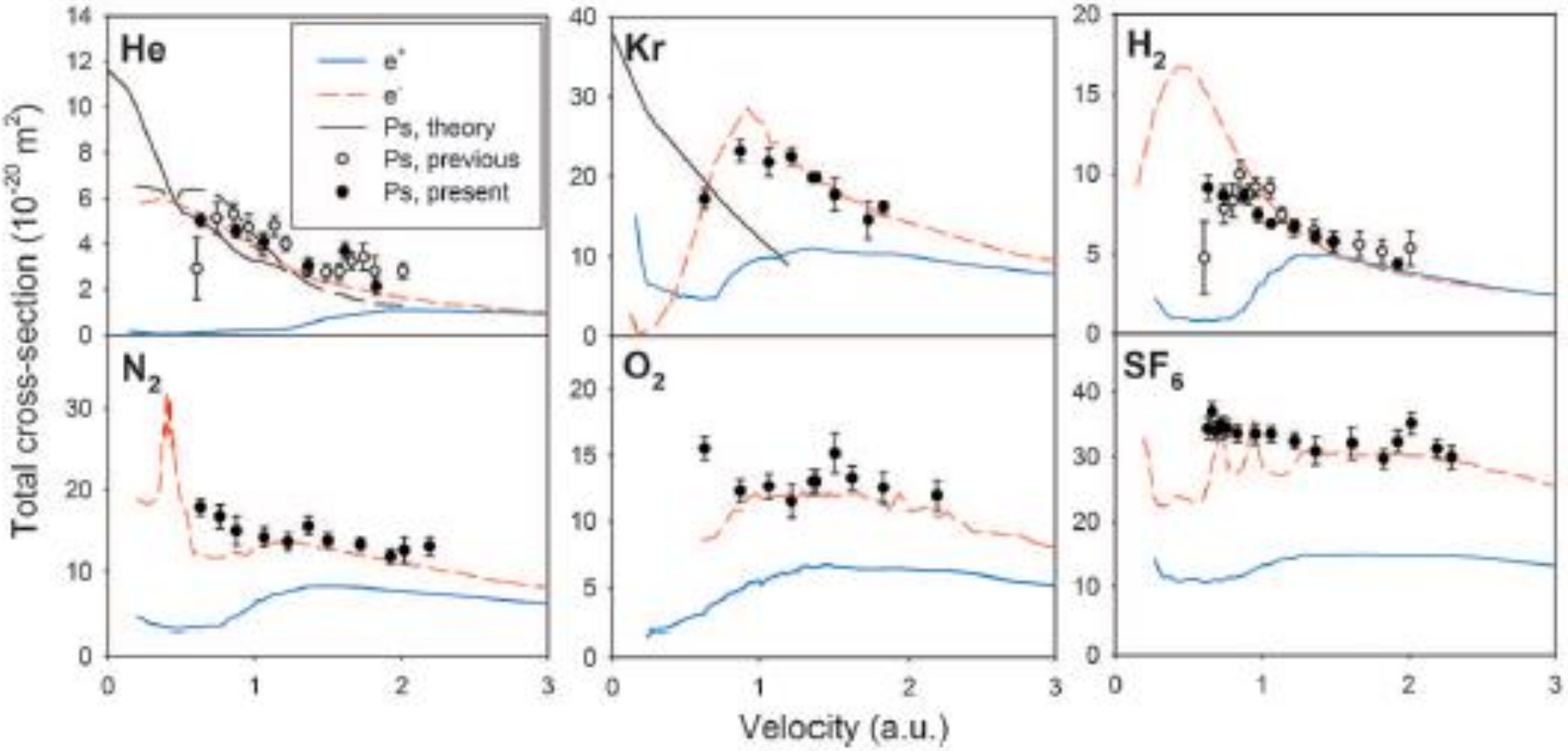
(Received 20 September 2019; published 19 December 2019)

Experimental determinations of the absolute differential positronium-formation cross sections near 0° for Ne, Ar, Kr, and Xe are presented and compared with theory. The degree of forward collimation, expressed by the ratios of the differential-to-integral positronium-formation cross sections, is also computed and compared with theories and other targets. Trends among targets and structures at low energies emerge when considered as a function of the reduced total energy.



Electron-Like Scattering of Positronium

S. J. Brawley, S. Armitage,* J. Beale,† D. E. Leslie,‡ A. I. Williams, G. Laricchia§



www.sciencemag.org **SCIENCE** VOL 330 5 NOVEMBER 2010

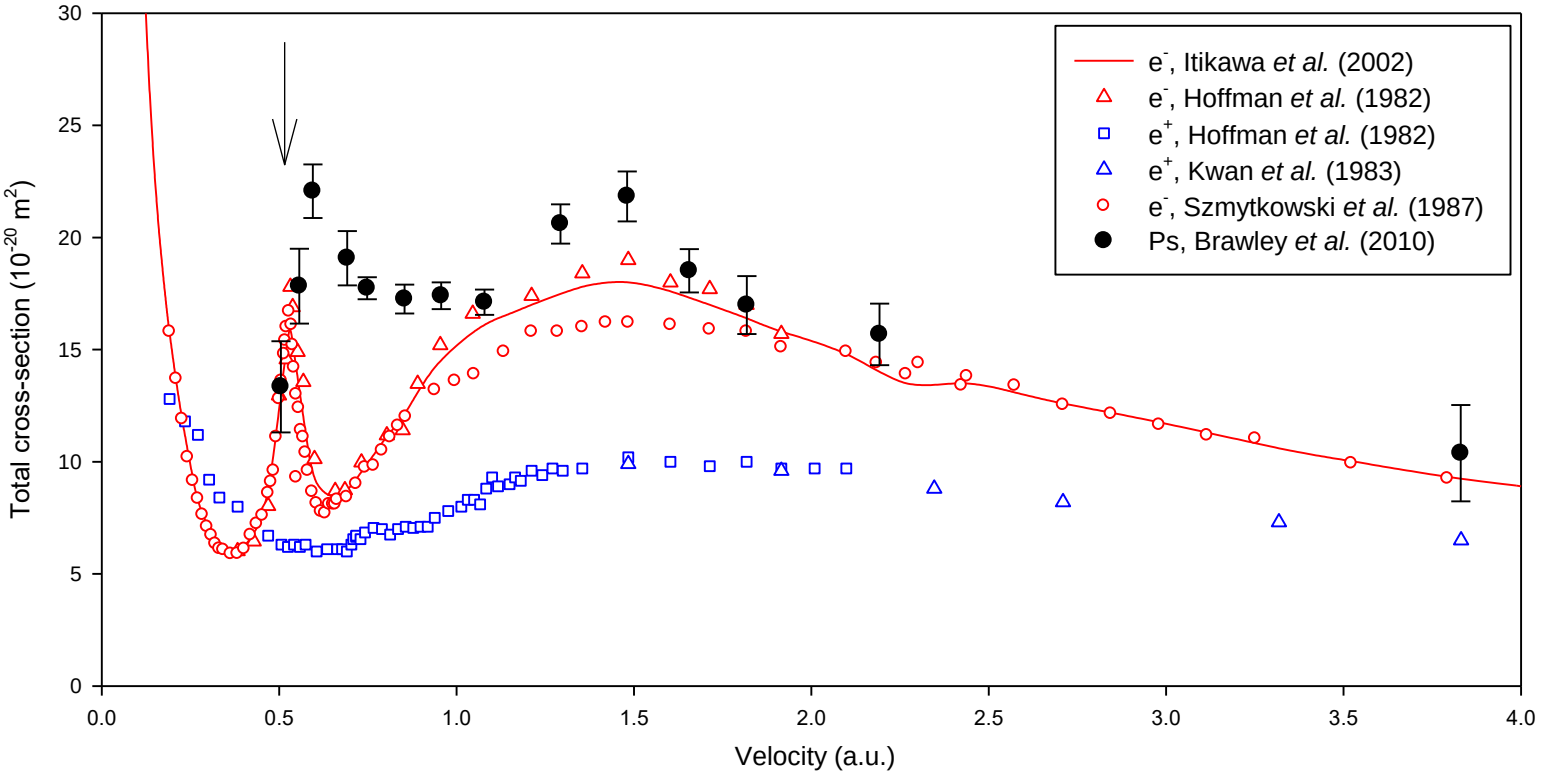
PRL 105, 263401 (2010) PHYSICAL REVIEW LETTERS week ending 31 DECEMBER 2010

Resonant Scattering of Positronium in Collision with CO_2

S. J. Brawley, A. I. Williams, M. Shipman, and G. Laricchia*

UCL Department of Physics and Astronomy, University College London, Gower Street, London, WC1E 6BT, United Kingdom

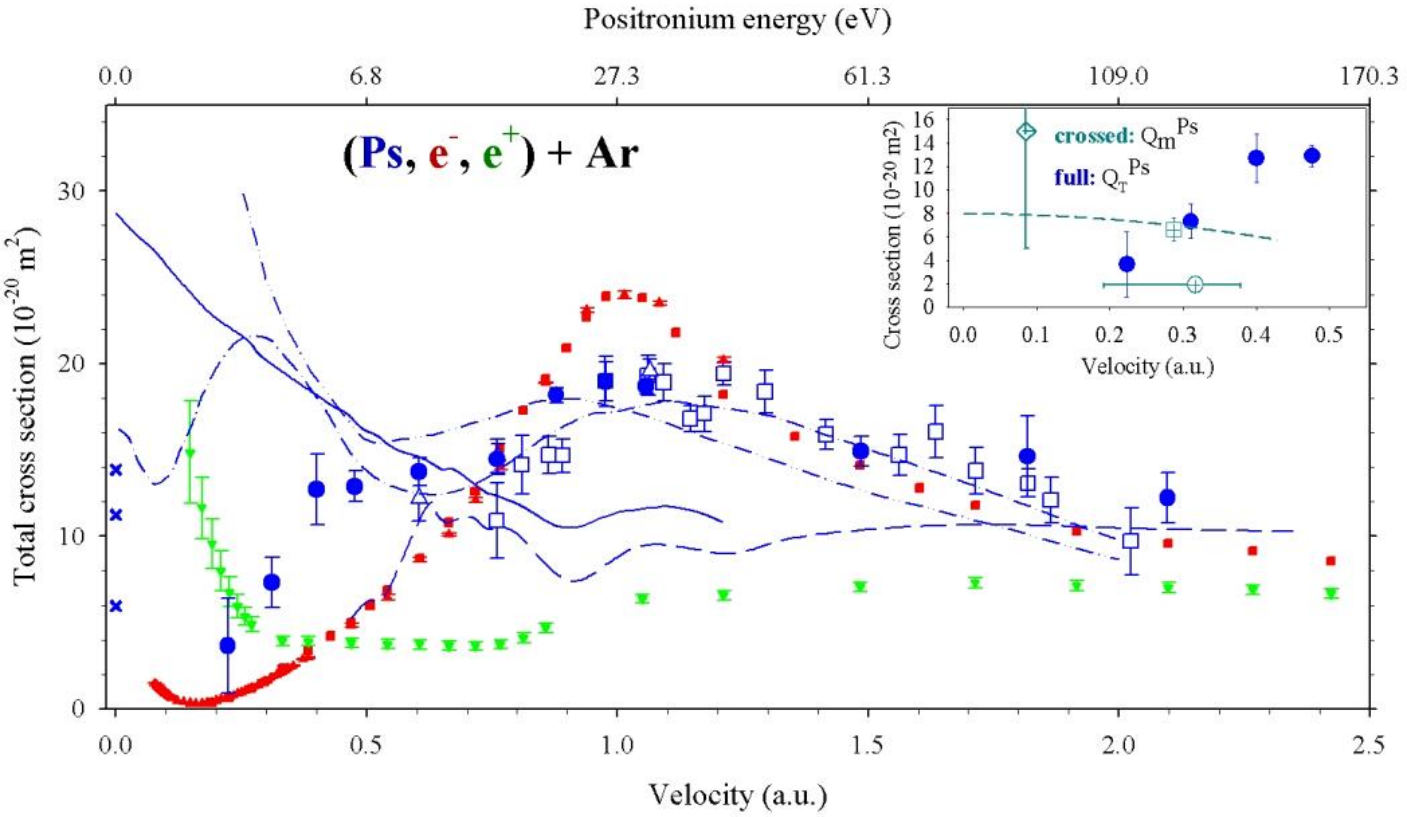
(Received 11 November 2010; published 22 December 2010)



PRL 115, 223201 (2015) PHYSICAL REVIEW LETTERS week ending 27 NOVEMBER 2015

Positronium Production and Scattering below Its Breakup Threshold

S. J. Brawley, S. E. Fayer, M. Shipman, and G. Laricchia*
UCL Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, United Kingdom



PHYSICAL REVIEW A **95**, 032704 (2017)

Resonant scattering of positronium as a quasifree electron

M. Shipman,[1] S. J. Brawley,[1] L. Sarkadi,[2] and G. Laricchia[1,*]

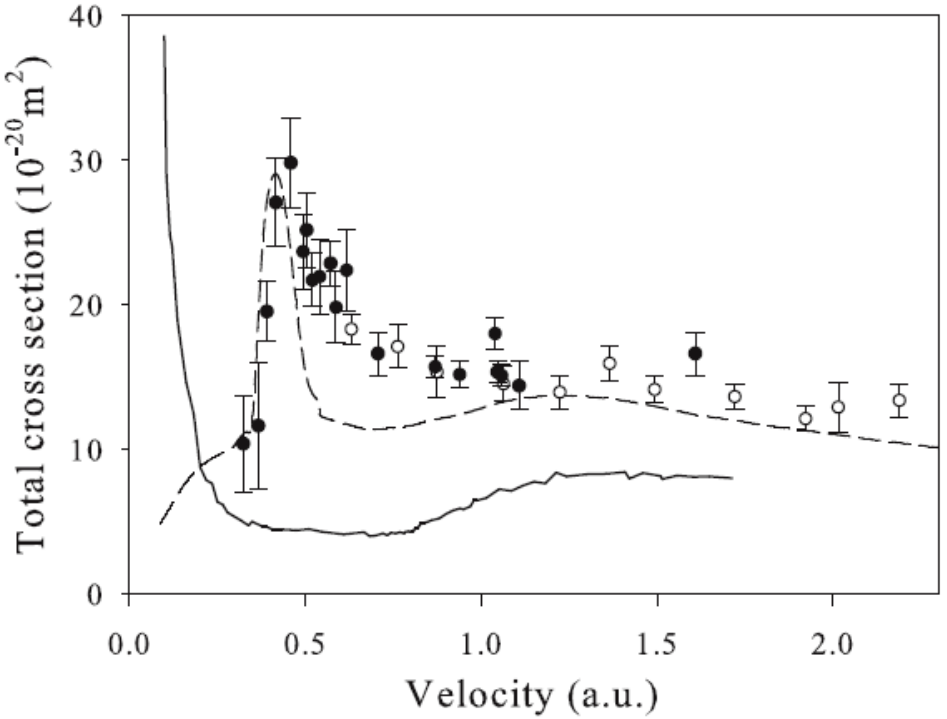


FIG. 1. Total cross sections for equivelocity Ps, positrons, and electrons colliding with N_2. Here the • represent the Q_T^{Ps} measurements from the present work and the ○ those from [16], while —— shows the corresponding Q_T^+ from [36] and — — — the Q_T^- from [33].

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OPEN

A statistical description of scattering at the quantum level

G. Laricchia[1], P. Van Reeth[1], S. E. Fayer[1,2], S. J. Brawley[1], R. Kadokura[1], A. Loreti[1] & M. Shipman[1]

Received: 13 July 2018
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Quantum physics is undoubtedly the most successful theory of the *microscopic* world, yet the complexities which arise in applying it even to simple atomic and molecular systems render the description of basic collision probabilities a formidable task. For this reason, approximations are often employed, the validity of which may be restricted to given energy regimes and/or targets and/or projectiles. Now we have found that the lognormal function, widely used for the probability distribution of *macroscopic* stochastic events (as diverse as periods of incubation of and recovery from diseases, size of grains, abundance of species, fluctuations in economic quantities, etc.) may also be employed to describe the energy dependence of inelastic collisions at the quantum level (including ionization, electron capture and excitation by electrons, positrons, protons, antiprotons, etc.), by allowing for the relevant threshold energy. A physical interpretation is discussed in this article by analogy with the heat capacity of few-level systems in solid state physics. We find the generality of the analysis to extend also to nuclear reactions. As well as aiding the description of collision probabilities for quantum systems, this finding is expected to impact also on the fundamental understanding of the interface between the classical and quantum domains.

Interference and Resonant Phenomena involving Antimatter

Two recent technical attainments are particularly pertinent to our future plans, namely the realization of a *positronium beam* now tuneable down to energies five times lower than previously obtained, and the development of a *new high-resolution positron-beamline* apt for inspecting collision dynamics.

These enhanced experimental capabilities have already started to bear fruit with *first glimpses* of subtle quantum mechanical effects, such as resonances and interference phenomena, *previously beyond established observational power*. We will probe the *mechanisms* giving rise to such effects in positron and positronium scattering and thus aid progress towards of a *more profound understanding of matter-antimatter physics in general.*

PhD project details from:

Gaetana Laricchia
g.laricchia@ucl.ac.uk
http://www.ucl.ac.uk/positron-physics
http://iris.ucl.ac.uk/iris/browse/profile?upi=GLARI24