IOP Institute of Physics

QuVis: The Quantum Mechanics Visualization Project

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University of St Andrews
600 YEARS

INTRODUCTION

Animations and simulations can help students build mental representations of physics concepts through high levels of interactivity, prompt feedback and multiple representations of physics concepts, including microscopic processes that cannot be directly observed. By choosing particular interactive elements and limiting their ranges, students can be implicitly guided in their exploration [1-3].

Since 2009 we have been developing and evaluating visualizations and animations (collectively called animations in what follows) for the teaching and learning of quantum mechanics concepts at university level [4,5]. This resource builds on existing education research as well as our teaching experience. The animations are in many ways complementary to other resources: Each animation shows a situation aimed at clarifying a particular concept and includes a step-by-step exploration that explains key points in detail. Animations include interactive elements such as sliders, buttons, play controls and check boxes that encourage exploration and investigation. Evaluation work guides the design and content of the animations. Evaluation used includes questionnaires, a diagnostic survey to evaluate learning gains, observation sessions with a small number of student volunteers and observations during a workshop in which students interact with animations.

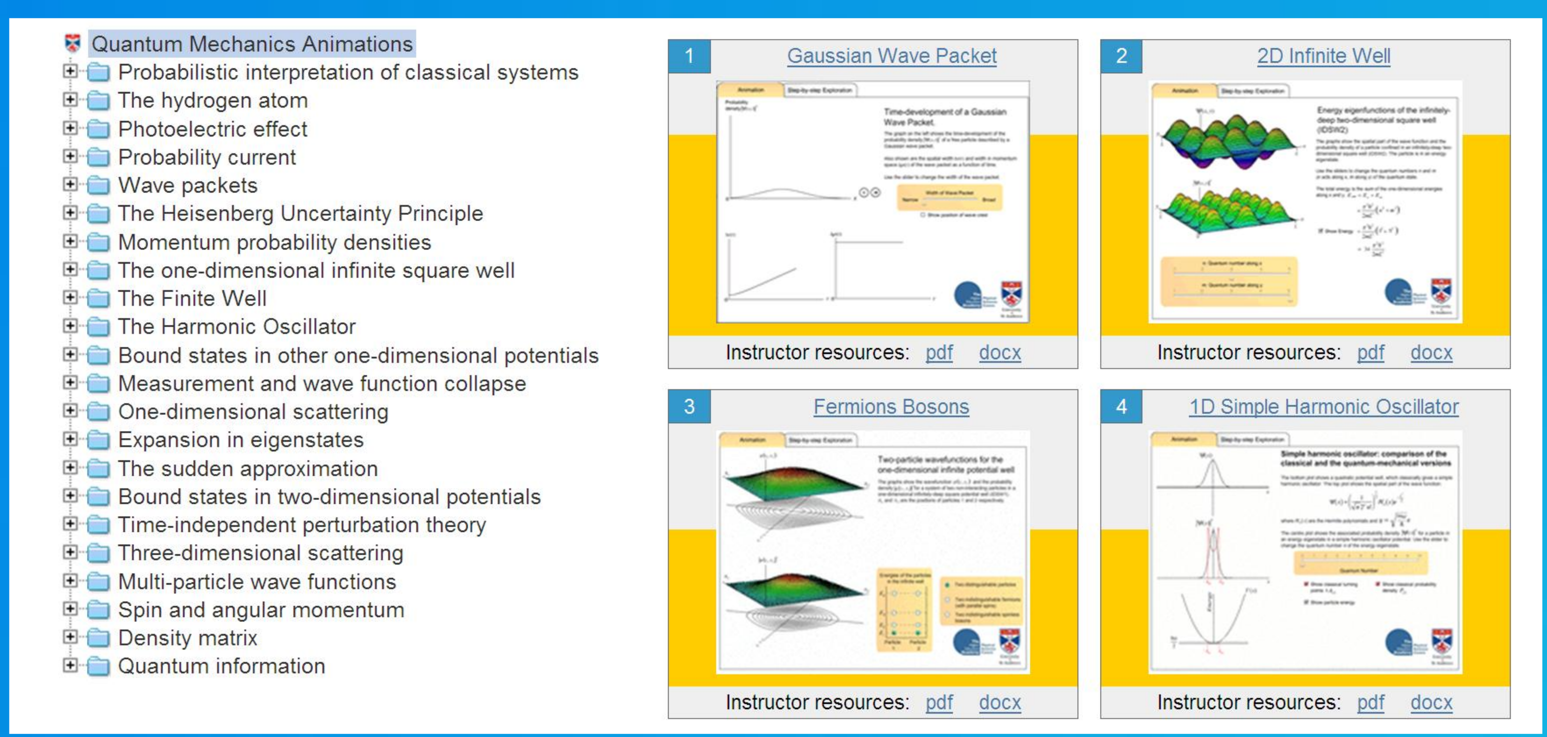


Fig. 1: Screenshot of the website www.st-andrews.ac.uk/~qmanim, showing topics of the animations available so far.

Many animations include instructor resources consisting of worksheets with full solutions. Animations and instructor resources are freely available at www.st-andrews.ac.uk/~qmanim, and can be played or downloaded from this site (see Fig. 1). Animations (50 in total) are available on a wide range of topics from introductory to advanced quantum mechanics.

ANIMATIONS FOR CHEMISTRY STUDENTS

Over the past year, through modifying existing animations and developing new animations and resources for chemistry instructors, we have started to extend the resource to be more useful to chemistry students studying introductory quantum mechanics (see www.st-andrews.ac.uk/~qmanim/chemistry and Fig. 2). We have carried out initial evaluation of these animations in a level two St Andrews chemistry module. The evaluation consisted of a student survey and individual observation sessions with 13 chemistry student volunteers interacting with previously unseen animations. The results are being used to revise the level and detail of explanations. We plan to substantially increase the number of animations available for chemistry students.

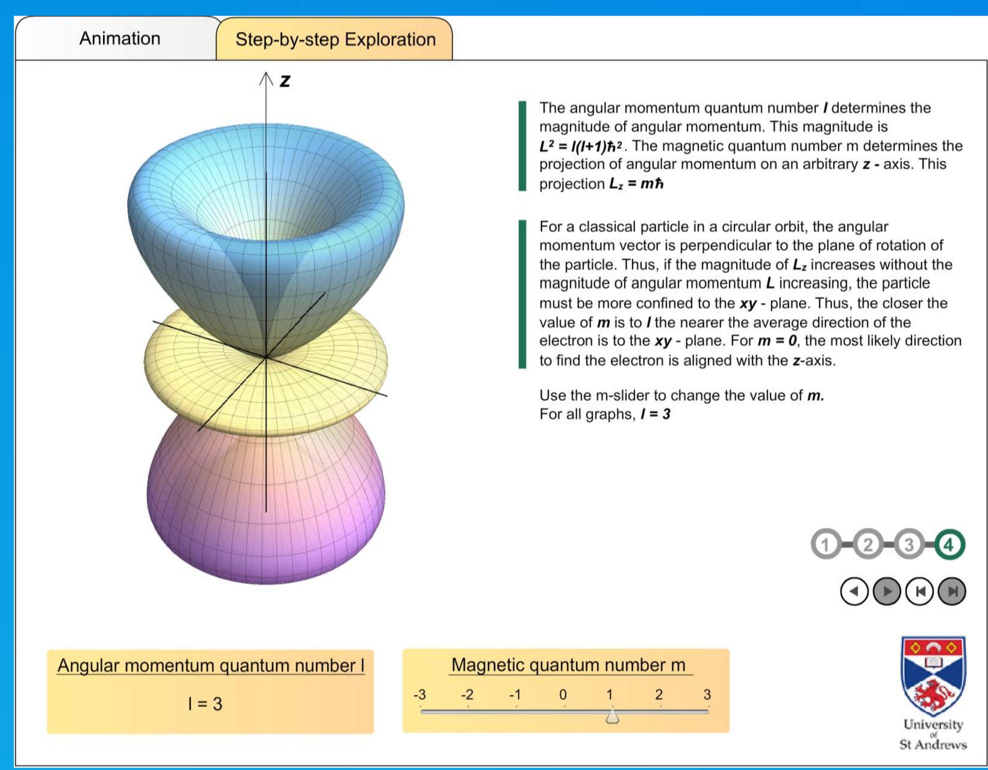


Fig. 2: Screenshot of the "Spherical Harmonics" animation, showing one of the steps of the Step-by-Step Exploration view.

NEW QUANTUM CURRICULUM ANIMATIONS

The Institute of Physics (IOP) New Quantum Curriculum project will provide learning and teaching materials for a contemporary approach to a first course in quantum mechanics starting from simple two-level systems. The project involves the Universities of Sheffield, Loughborough, Leicester, St Andrews, York and University College London. St Andrews is developing animations for this project (see Fig. 3). Materials will be freely available on an IOP website in summer 2013.

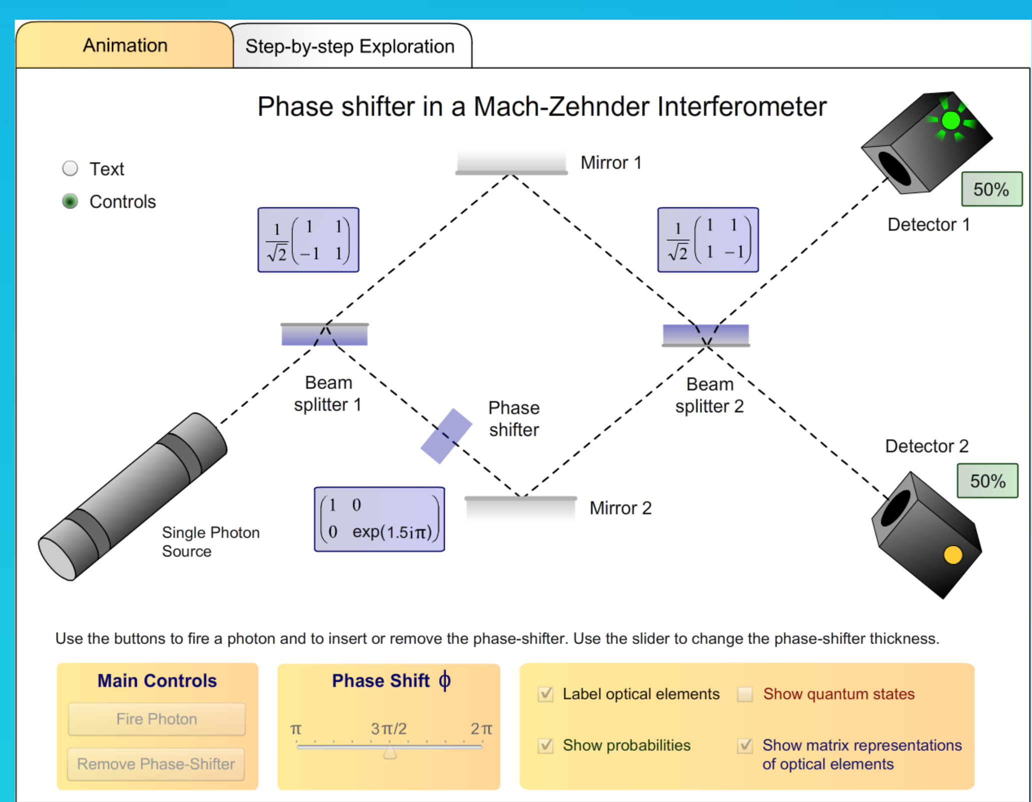


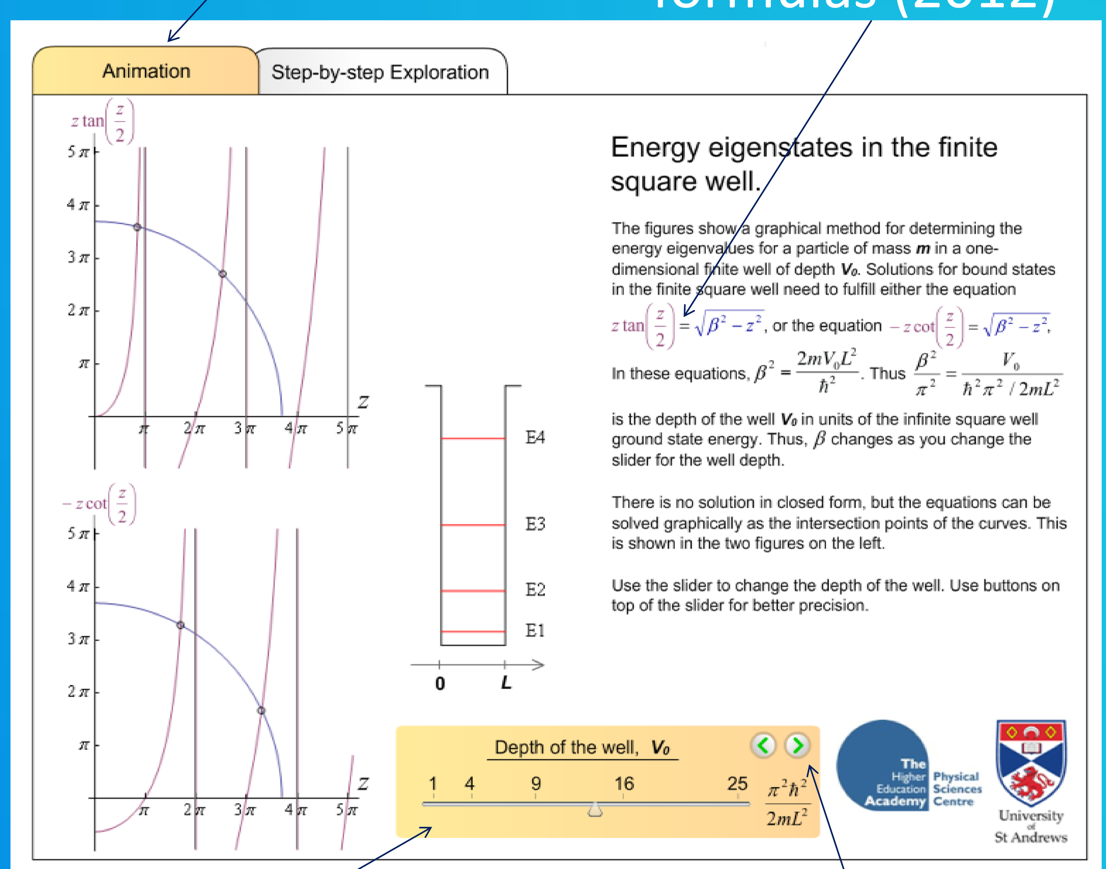
Fig. 3: Screenshot of the "Phase shifter in a Mach-Zehnder Interferometer" animation, showing the main Animation view.

EXAMPLE: REVISIONS TO THE FINITE WELL ANIMATION DUE TO EVALUATION OUTCOMES

The Finite Well animation was developed in summer 2010. In summer 2011, we revised all animations as a result of student observation sessions. We also considered research outcomes of the PhET team in these revisions [1-3]. In summer 2012, further revisions addressed student difficulties during a workshop session.

Colored tabs (2011)

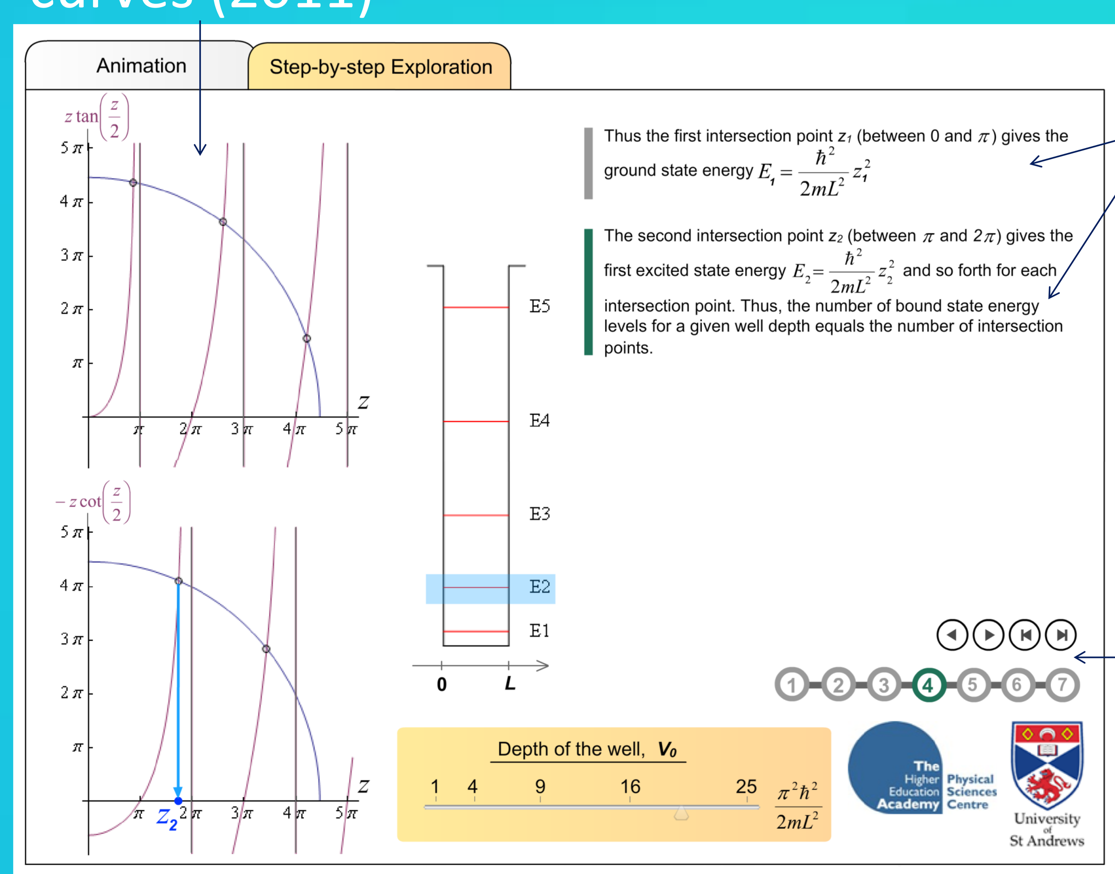
Color in formulas (2012)



Color to highlight controls (2011)

Additional button controls (2011)

Improved graphics, using colored curves (2011)



Additional animated steps explaining relation between intersection points and energy levels (2012)

Step counter and clearer step controls (2011)

Steps with user interactivity (not shown, 2012)

ACKNOWLEDGMENTS

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