N. Srimanobhas
P. Ittisamai

แบบฝึกหัด

ให้ทำเอกสาร LaTeX ตามเอกสารด้านล่างนี้

Quantum Theory of the Hydrogen Atom

Norraphat SRIMANOBHAS

October 12, 2016

Contents

1 **Schrödinger's equation for the hydrogen atom** 1

2 **Orbital quantum number** 2

Introduction

The first problem that Schrödinger tackled with his new wave equation was that of the hydrogen atom. He found the mathematics heavy going, but was rewarded by the discovery of how naturally quantization occurs in wave mechanics.

..... From [1, 1]

1 Schrödinger's equation for the hydrogen atom

A hydrogen atom consists of a proton, and particle of electric charge $+e$, and an electron, a particle of charge $-e$ which is 1836 times ligther than the proton. Schrödinger's equation for the electron in three dimensions, which is what we must use for the hydrogen atom, is

$$\frac{\delta^2\psi}{\delta x^2} + \frac{\delta^2\psi}{\delta y^2} + \frac{\delta^2\psi}{\delta z^2} + \frac{2m}{\hbar}(E-U)\psi = 0 \tag{1}$$

.....

You can see from Fig 2, ...

	l=0	l=1	l=2
n=1	1s		
n=2	2s	2p	
n=3	3s	3p	3d

Table 1: Atomic electron states

2 Orbital quantum number

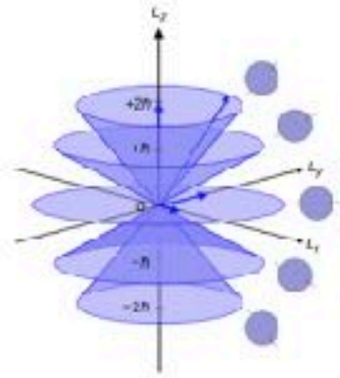

Figure 1: Illustration of quantum mechanical orbital angular momentum.

References

[1] V. Glikov, S. Kcvik and P. Prenajder, Acta Phys. Slov. **65**, nc. 3, 153 (2015) [arXiv:1510.04496].

References

[1] Veronika Glikov, Samuel Kcvik, and Peter Prenajder. Quantum Mechanics in Noncommutative space. *Acta Phys. Slov.*, 65(3):153 – 234, 2015.

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Contents นี้สร้างขึ้นมาโดยคำสั่งใน LaTeX เราไม่จำเป็นต้องเขียนเอง

Introduction

ให้สังเกตว่า Introduction นั้นไม่อยู่ใน Contents และไม่มีเลขกำกับ

The first problem that Schrödinger tackled with his new wave equation was that of the hydrogen atom. He found the mathematics heavy going, but was rewarded by the discovery of how naturally quantization occurs in wave mechanics.

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ใช้ cite

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.....

You can see from Fig. 2,

ใช้ ref

Schrödinger

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n=1	1s		
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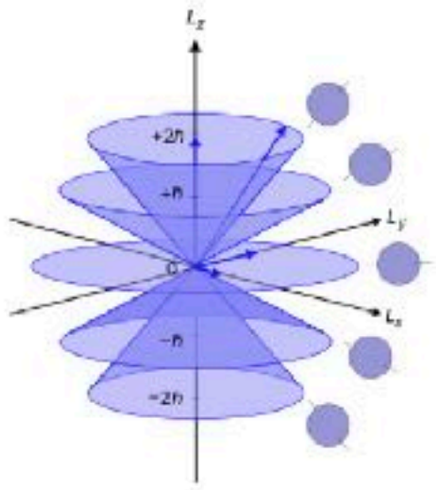


Figure 1: Illustration of quantum mechanical orbital angular momentum.

References

[1] V. Glikov, S. Kovik and P. Prenajder, Acta Phys. Slov. **65**, no. 3, 153 (2015) [arXiv:1510.04496].

References

[1] Veronika Glikov, Samuel Kovik, and Peter Prenajder. Quantum Mechanics in Noncommutative space. *Acta. Phys. Slov.*, 65(3):153 – 231, 2015.

- รูปสามารถโหลดได้จาก https://twiki.cern.ch/twiki/pub/Main/LaTeXWorkshopAtCU2016/orbital_angular_momentum.png
- สังเกตว่ารูปนั้นเป็นไฟล์ PNG ผู้เรียนอาจจะต้องมีการโหลด package เพิ่มเติมเพื่อให้สามารถใส่รูป PNG ลงไปในเอกสารได้
- ให้สังเกตการวางตำแหน่งของรูปว่าวางอยู่ภายใต้หัวข้อที่ 2 แต่ตารางที่ 1 นั้นวางอยู่นอกหัวข้อที่ 2
- ให้ label รูป และ ref จาก Label นั้น

- ในแบบฝึกหัดจะมี References 2 แบบ
  - แบบแรกทำจาก thebibliography ซึ่งสามารถเขียนลงไปในเอกสาร LaTeX ได้เลย
  - แบบที่ 2 ทำจาก bibtex ซึ่งจะมีไฟล์ bibtex แยกออกมาต่างหากอีกไฟล์หนึ่ง
  - http://inspirehep.net/record/1408805

เราสามารถหา Reference ที่อยู่ในฟอร์มของ bibtex ได้หลายที่ สามารถหาข้อมูลเพิ่มเติมได้จาก http://tex.stackexchange.com/questions/143/what-are-good-sites-to-find-citations-in-bibtex-format

แบบ LaTeX สามารถแปะลงไปในเอกสาร LaTeX ได้เลย

```
%\cite{Galikova:2015eyn}
\bibitem{Galikova:2015eyn}
  V.~Gáliková, S.~Kováčik and P.~Prešnajde
  %``Quantum Mechanics in Noncommutative s
  Acta Phys.\ Slov.\  {\bf 65}, no. 3, 153
  [arXiv:1510.04496].
  %%CITATION = ARXIV:1510.04496;%%
  %1 citations counted in INSPIRE as of 12
```

แบบ bibtex ที่เราจะรวบรวมใส่ไฟล์ .bib เอาไว้ แล้วเรียกไฟล์จาก LaTeX อีกที

```
%%% contains utf-8, see: http://inspirehep.
%%% add \usepackage[utf8]{inputenc} to your

@article{Galikova:2015eyn,
      author         = "Gáliková, Veronika
                        Prešnajder, Peter",
      title          = "{Quantum Mechanics
      journal        = "Acta Phys. Slov.",
      volume         = "65",
      year           = "2015",
      number         = "3",
      pages          = "153 - 234",
      eprint         = "1510.04496",
      archivePrefix  = "arXiv",
      SLACcitation   = "%%CITATION = ARXIV:
}
```

General-purpose reference collections that provide BibTeX citations

- Google Scholar
- CiteULike
- Amazon
- Nelson Beebe's collection
- Bibsonomy

Subject-specific collections that provide BibTeX citations

- MathSciNet (math) (Freely available via MRef)
- ACM catalog (CS)
- IEEE catalog (engineering/technical)
- Collection of CS Bibliographies (computer science)
- DBLP (math/CS)
- SPIRES (high-energy physics)
- Citing Wikipedia itself
- TeXMed, of PubMed (medicine, biology, bioinformatics)
- PhilPapers (philosophy, related disciplines)
- Stanford Encyclopedia of Philosophy (as it says on the tin)

Reference managers that allow BibTeX export/import

- Bibliophile for converting from other formats
- JabRef
- Mendeley
- Qiqqa - has a 'BibTeX Sniffer' wizard and auto-association of BibTeX with PDFs
- Zotero (Firefox extension)

Quantum Mechanics in Noncommutative space

Veronika Gáliková, Samuel Kováčik, Peter Prešnajder (Comenius U.)

Oct 15, 2015

Acta Phys.Slov. 65 (2015) no.3, 153 - 234
e-Print: arXiv:1510.04496 | PDF

Abstract (arXiv)
This paper provides an examination of how are prediction of standard quantum mechanic (QM) affected by introducing a noncommutative (NC) structure into the configuration space of the considered system (electron in the Coulomb potential in the present case). The parameter controlling the extent of modification is denoted as {\lambda}. The coordinates in the NC space are realized via creation and annihilation operators acting in an auxiliary Fock space, this one being chosen in such a way that the rotational invariance of the system remains intact also in NCQM. Analog of Schr\"odinger equation for hydrogen atom is found and analytically solved, both for bound states and scattering. The exact formulas for NC corrections are given. None of the NC predictions contradicts experimentally verified QM results, since in the correspondence limit {\lambda} -> 0 both QM and NCQM coincide. Highly surprising feature of the NC version is the existence of bound states for repulsive potential at ultra-high energies. However, these disappear from the Hilbert space in the mentioned limit. The whole problem is solved also using a method analogous to that of Pauli. Besides rotational invariance, the dynamical symmetry related to the conservation of NC analog of Laplace-Runge-Lenz vector is being used and the results obtained this way are in the full agreement with those given by "Schr\"odinger-like" approach. The presented NC deformation of QM preserves all those mysterious properties of the Coulomb system that mace it a distinguished key-stone of the modern physics.

Note: 111 pages
Note: *Brief entry*

Record added 2015-12-09, last modified 2018-06-14

การสร้างเอกสารอ้างอิงแบบ thebibliography

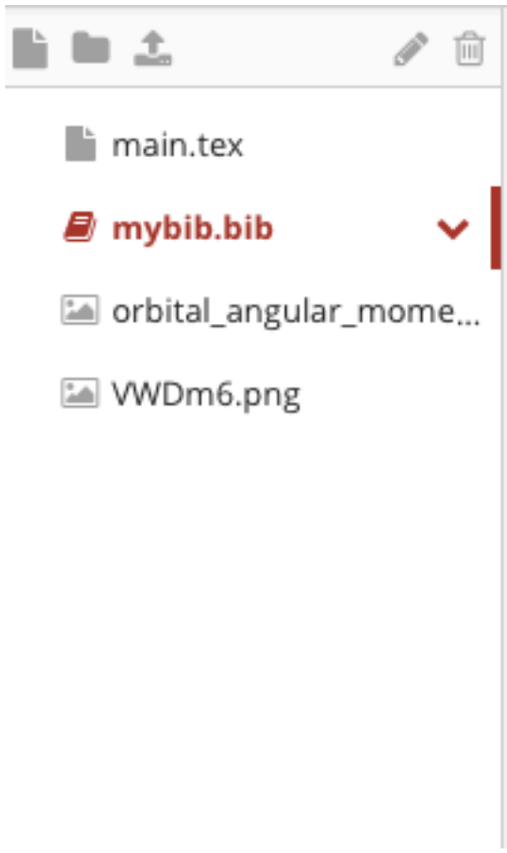
```
59 \begin{thebibliography}{9}
60
61 \bibitem{Galikova:2015eyn1}
62   V.~Gáliková, S.~Kováčik and P.~Prešnajder,
63   %``Quantum Mechanics in Noncommutative space,''
64   Acta Phys.\ Slov.\  {\bf 65}, no. 3, 153  (2015)
65   [arXiv:1510.04496].
66   %%CITATION = ARXIV:1510.04496;%%
67   %1 citations counted in INSPIRE as of 12 Oct 2016
68 \end{thebibliography}
```

เพิ่มเอกสารอ้างอิงลงไปใน LaTeX ได้เลย

```
\dots\dots From \cite{Galikova:2015eyn1,
Galikova:2015eyn
                  \cite{…,Galikova:2015eyn      reference
                  \cite{…,Galikova:2015eyn2     reference
\section{Schr$\   \cite{…,Nobody06              reference  e
hydrogen atom}      Press CTRL-Space to Search
```

เรียก cite เอกสารอ้างอิง

การสร้างเอกสารอ้างอิงแบบ bibtex




```
@article{Galikova:2015eyn2,
      author         = "Gáliková, Veronika and Kováčik, Samuel and
                        Prešnajder, Peter",
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      journal        = "Acta Phys. Slov.",
      volume         = "65",
      year           = "2015",
      number         = "3",
      pages          = "153 - 234",
      eprint         = "1510.04496",
      archivePrefix  = "arXiv",
      SLACcitation   = "%%CITATION = ARXIV:1510.04496;%%"
}

@misc{ Nobody06,
       author = "Nobody Jr",
       title = "My Article",
       year = "2016" }
```
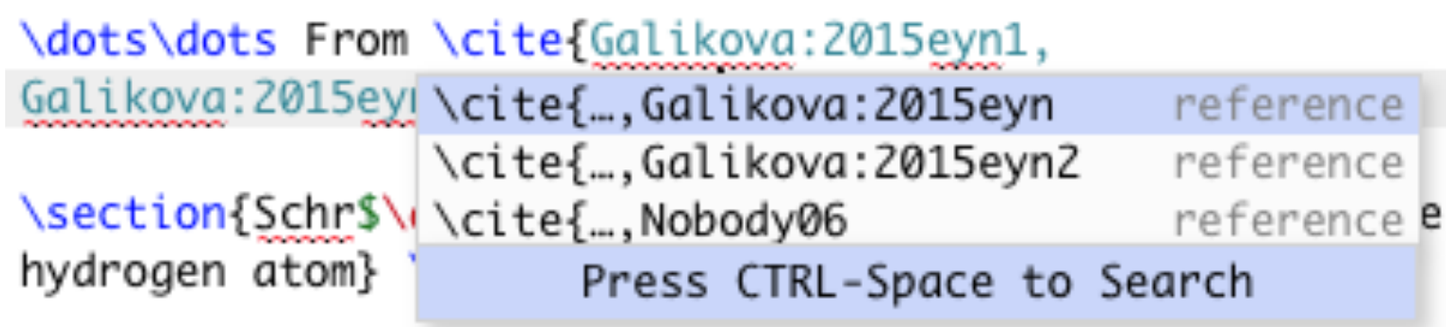

mybib.bib เก็บข้อมูลของเอกสารอ้างอิงเอาไว้ **ถ้าหากเราไม่ *cite* เอกสารอ้างอิงอันใด เวลา *compile* เอกสาร เอกสารอันนั้นก็จะไม่อยู่ในลิสต์ของเอกสารอ้างอิง**



เรียก cite เอกสารอ้างอิง

ใส่ใน LaTeX ให้เพิ่ม Reference ลงไปในเอกสาร

```
\bibliographystyle{unsrt}
\bibliography{mybib}

\end{document}
```

เฉลยแบบฝึกหัด

```
\documentclass[a4paper,12pt]{article}
\usepackage{graphicx}
\usepackage{float}

\title{Quantum Theory of the Hydrogen Atom}

\author{Norraphat SRIMANOBHAS}

\begin{document}

\maketitle

\tableofcontents

\section*{Introduction}

The first problem that Schr$\ddot{\mbox{o}}$dinger tackled with
his new wave equation was that of the hydrogen atom. He found
the mathematics heavy going, but was rewarded by the discovery
of how naturally quantization occurs in wave mechanics.

\dots\dots From \cite{Galikova:2015eyn1,
Galikova:2015eyn2,Nobody06,}

\section{Schr$\ddot{\mbox{o}}$dinger's equation for the
hydrogen atom} \label{sec.schrodingereq}

A hydrogen atom consists of a protron, and particle of electric
charge $+e$, and an electron, a particle of charge $-e$ which
is 1836 times ligther than the proton.
Schr$\ddot{\mbox{o}}$dinger's equation for the electron in
three dimensions, which is what we must use for the hydrogen
atom, is
```

เฉลยแบบฝึกหัด

```latex
\begin{equation}
    \frac{\partial^2\psi}{\partial x^2} +
    \frac{\partial^2\psi}{\partial y^2} +
    \frac{\partial^2\psi}{\partial z^2} +
    \frac{2m}{\hbar}(E-U)\psi = 0
\end{equation}

\dots\dots

You can see from Fig. \ref{fig:orbital}, ...

\section{Orbital quantum number}

\begin{table}[h]
\begin{center}
\begin{tabular}{ c c c c }
    \hline
    & l=0 & l=1 & l=2 \\
    \hline
    n=1 & 1s & & \\
    n=2 & 2s & 2p & \\
    n=3 & 3s & 3p & 3d \\
    \hline
  \end{tabular}
  \end{center}
  \caption{Atomic electron states}
\end{table}

\begin{figure}[H]
\begin{center}
\includegraphics[width=5cm]{orbital_angular_momentum.png}
\caption{Illustration of quantum mechanical orbital angular momentum.}
\end{center}
\label{fig:orbital}
\end{figure}

```

เฉลยแบบฝึกหัด

```
59  \begin{thebibliography}{9}
60
61  \bibitem{Galikova:2015eyn1}
62    V.~Gáliková, S.~Kováčik and P.~Prešnajder,
63    %``Quantum Mechanics in Noncommutative space,''
64    Acta Phys.\ Slov.\  {\bf 65}, no. 3, 153  (2015)
65    [arXiv:1510.04496].
66    %%CITATION = ARXIV:1510.04496;%%
67    %1 citations counted in INSPIRE as of 12 Oct 2016
68  \end{thebibliography}
69
70  \bibliographystyle{unsrt}
71  \bibliography{mybib}
72
73  \end{document}
```

mybib.bib

```
1   @article{Galikova:2015eyn2,
2         author          = "Gáliková, Veronika and Kováčik, Samuel
          and
3                            Prešnajder, Peter",
4         title           = "{Quantum Mechanics in Noncommutative
          space}",
5         journal         = "Acta Phys. Slov.",
6         volume          = "65",
7         year            = "2015",
8         number          = "3",
9         pages           = "153 - 234",
10        eprint          = "1510.04496",
11        archivePrefix   = "arXiv",
12        SLACcitation    = "%%CITATION = ARXIV:1510.04496;%%"
13  }
14
15  @misc{ Nobody06,
16          author = "Nobody Jr",
17          title = "My Article",
18          year = "2016" }
```