Quantum Mechanics II, Mid-Term Take-Home Examination
10 am, Tue., April 6, 2023-10:00 am, Tue., April 27, 2023.
Instructor: Jiunn-Wei Chen

(a) Please write your answers in English and put down your references. (b) Please turn in your answers through the course NTU COOL course website, just like we did with the homework.

(1) (40 points, 12 pages maximum. Please type your answers in English.)

We have talked about the 21-centimeter line due to hyperfine splitting in hydrogen atom at the end of Chapter 7 in the textbook. Please write about why it is an important tool in (a) astronomy (10 points) and (b) cosmology (10 points).

We have also discussed Zeeman effect in Chapter 7. Discuss its applications in (c) astrophysics (10 points) and (d) laser cooling (10 points).

(2) (60 points, no page limit. You can send in either the typed or handwritten answers in English.) H^- is a hydrogen atom with an extra electron. The binding energy of its ground state is measured to be 14.4 eV, lower than the ground state energy of hydrogen atom and a free electron by ~ 0.8 eV. Please try to compute this ~ 0.8 eV difference, at least showing the sign is positive such that H^- is more stable than $H + e$.

This is not an easy problem. But I would like to see how far you can go. You can use whatever approach you like, including numerical approaches. Please solve the problem from top to bottom, not just using somebody's software to crank out the answer. Please show the important steps of your calculation as you were writing a research paper. You can just submit the photos of your handwritten notes without typing.

(1) (40分，最多12页。请用英文打出你的答案。)
我们在教材第七章末尾谈到了由于氢原子的超精细分裂而产生的21厘米线。
氢原子的超精细分裂导致的21厘米线。请写出
为什么它是（a）天文学（10分）和（b）宇宙学（10分）中的一个重要工具。
分）。
我们在第七章中也讨论了泽曼效应。讨论一下它在以下方面的应用
(c) 天体物理学（10分）和(d) 激光冷却（10分）。
(2)（60分，不限页数。你可以用英文打字或手写的答案寄来）。H-是一个有一个额外电子的氢原子。其基态的
其基态的结合能被测量为14.4eV，低于
比氢原子和一个自由电子的基态能量低0.8eV。请
试着计算一下这个0.8eV的差异，至少要显示符号是正的
这样，H-比H+e更稳定。
这不是一个简单的问题。但我想看看你能走多远。
你可以使用任何你喜欢的方法，包括数字方法。请
请从头到尾解决这个问题，而不仅仅是使用某个人的软件来得出答案。
出答案。请把你的计算的重要步骤显示出来，就像
你是在写一篇研究论文。你可以只提交你的
手写笔记的照片，不用打字。