

# Catalysts for African Development and Advancement (CADA)

**Omololu AKIN-OJO**



ICTP—East African Institute  
for Fundamental Research  
an ICTP Partner Institute



The Abdus Salam  
International Centre  
for Theoretical Physics



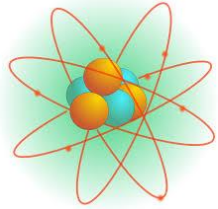
**Republic of Rwanda**



**Ministry of Education**

*...Research and Discoveries for African Development and Advancement*

# Our Goal

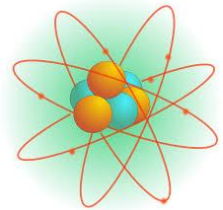


*Research and Discoveries*

*for*

*African Development and Advancement*

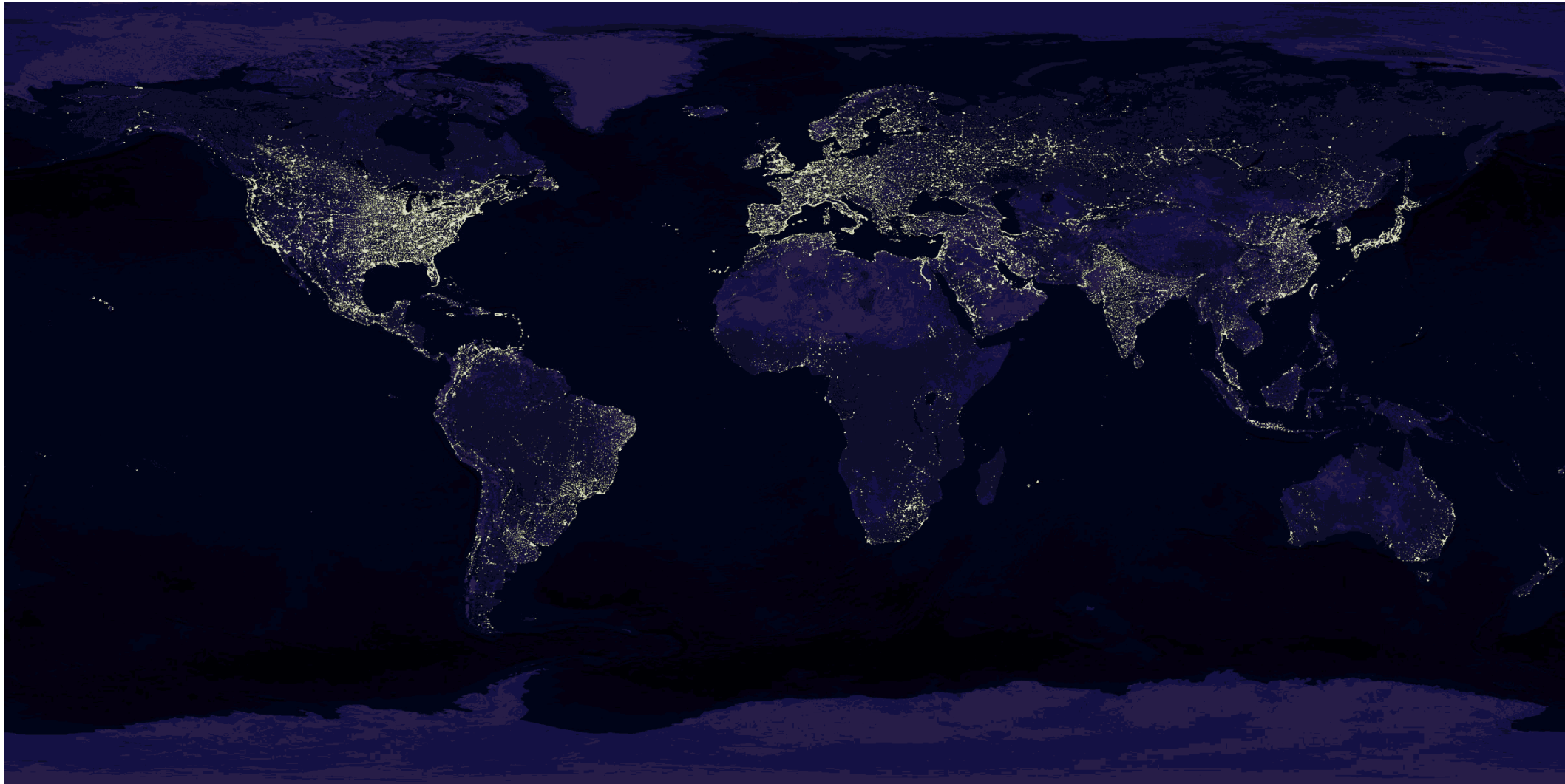
*(RADADA)*



- \* **Research and Discoveries (R&D) – Collab & Visits**
- \* **Training (for R&D) → MSc and PhD  
+ Workshops/Short courses**
- \* **Outreach → Via Students and Research Products**

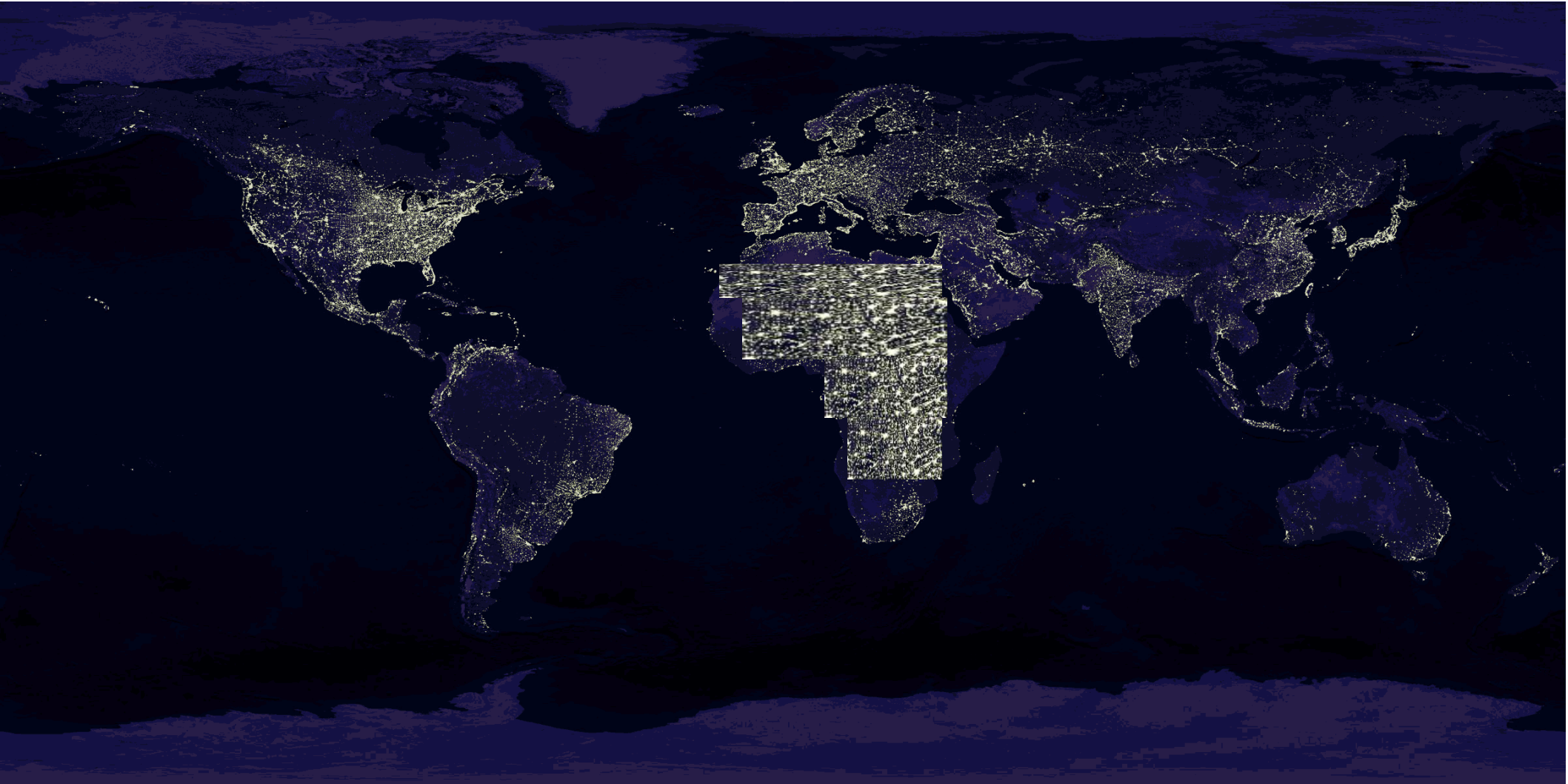
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# Dark Continent?



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# Near Future



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# Clean Water

## (Water Purification)

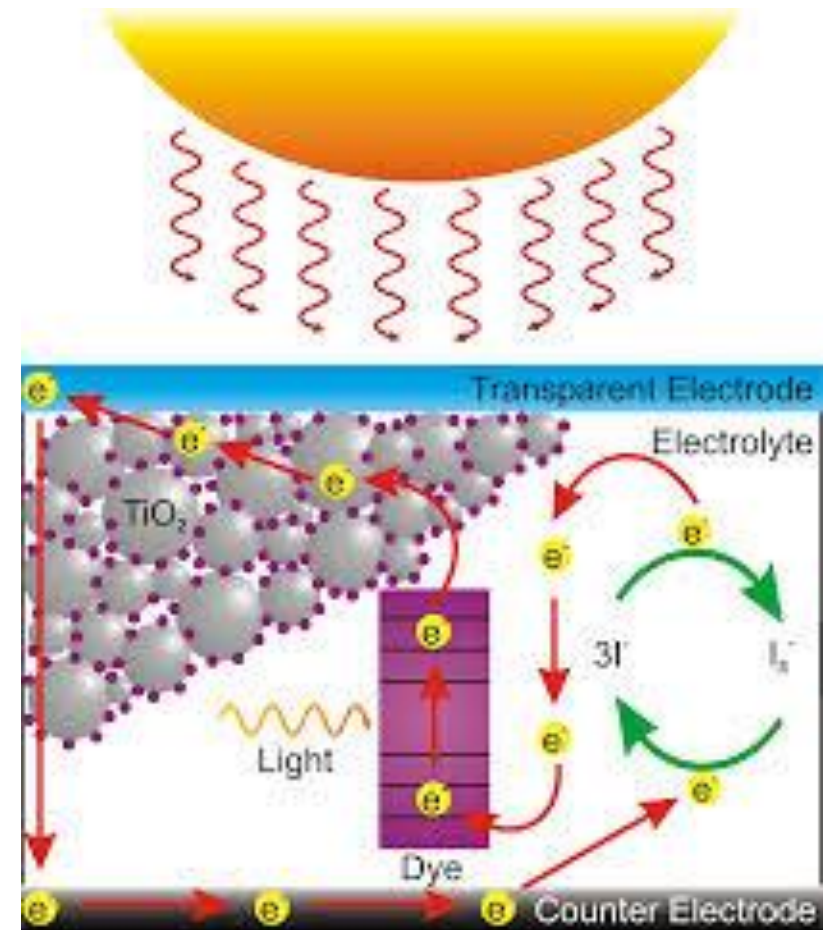
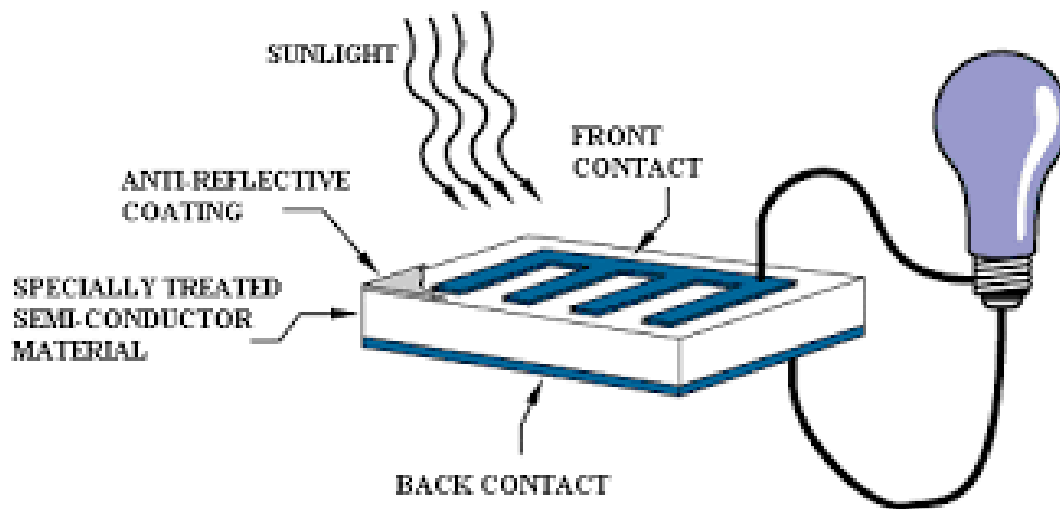


**“40% of Africans (over 330 million people) do not have access to safe drinking water, and half of people living in rural areas lack access.”**

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# SOLUTIONS

**1) Solar Cells** – Develop Cheap & Efficient Solar Cells: Quantum Dot solar cells, DSSCs, Perovskite Solar Cells



**2) Fuel Cells**

# SOLAR CELLS IN THEORY AND PRACTICE

(SCITAP-2018-A)

25 June – 29 June, 2018

University of Rwanda, Kigali, Rwanda

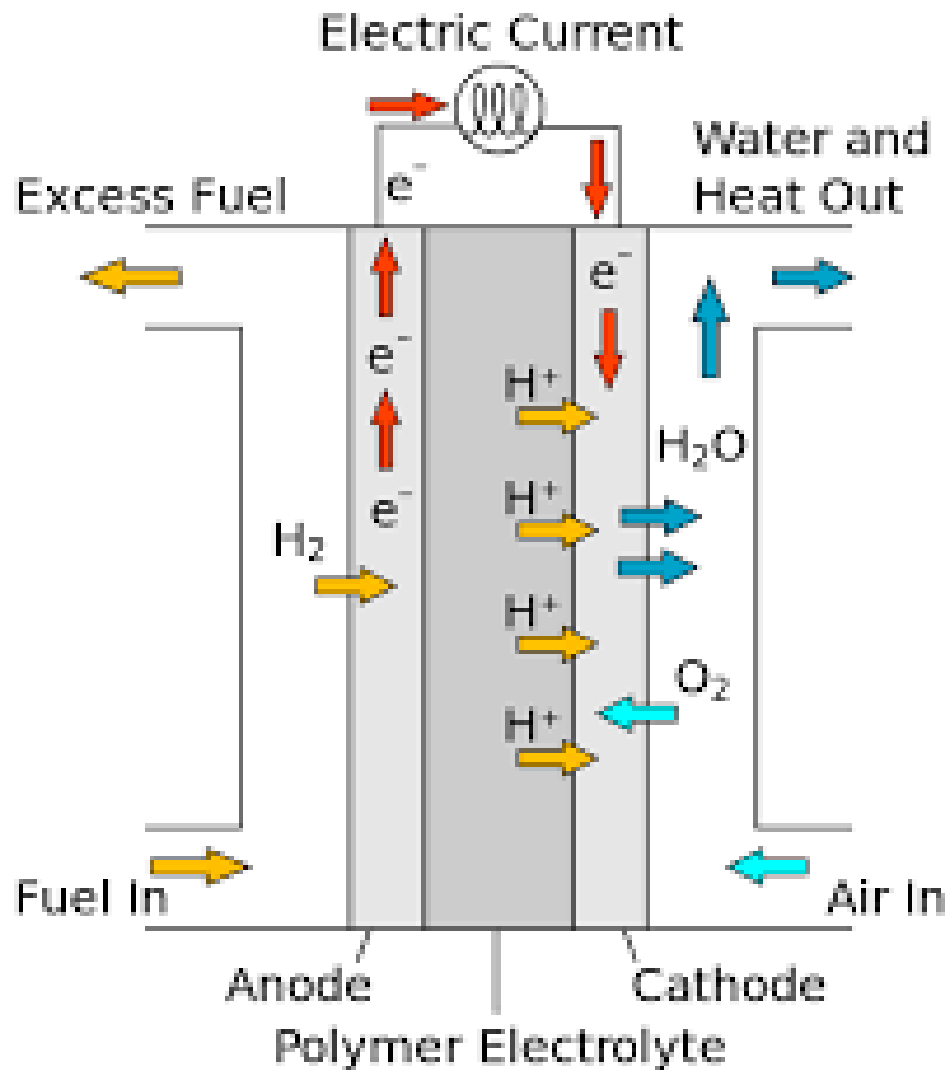
## Background and purpose

A 5-day intensive mini school, organized by the ICTP East African Institute for Fundamental Research (EAI FR) will be held at the ICTP-EAI FR premises of the University of Rwanda, Kigali. The goal of the short school is to train scientists and engineers in solar cells research and practical applications, i.e., it aims to train participants in photovoltaic science and technology.

## Topics covered

- \* Working Principles of Solar Cells
- \* Development of Dye Sensitized Solar cells (DSSCs): Theory and Hands on Session
- \* Device Simulation of Solar Cells
- \* Absorption Spectra of materials relevant to DSSCs
- \* Set up of Practical Solar Systems (Theory and Hands on):
  - + Solar Irradiance
  - + Solar Panel Choices and Positioning;
  - + Connecting cells to make modules
  - + Charge Controller
  - + Battery Choices
  - + Suitable Inverters

# Fuel Cell

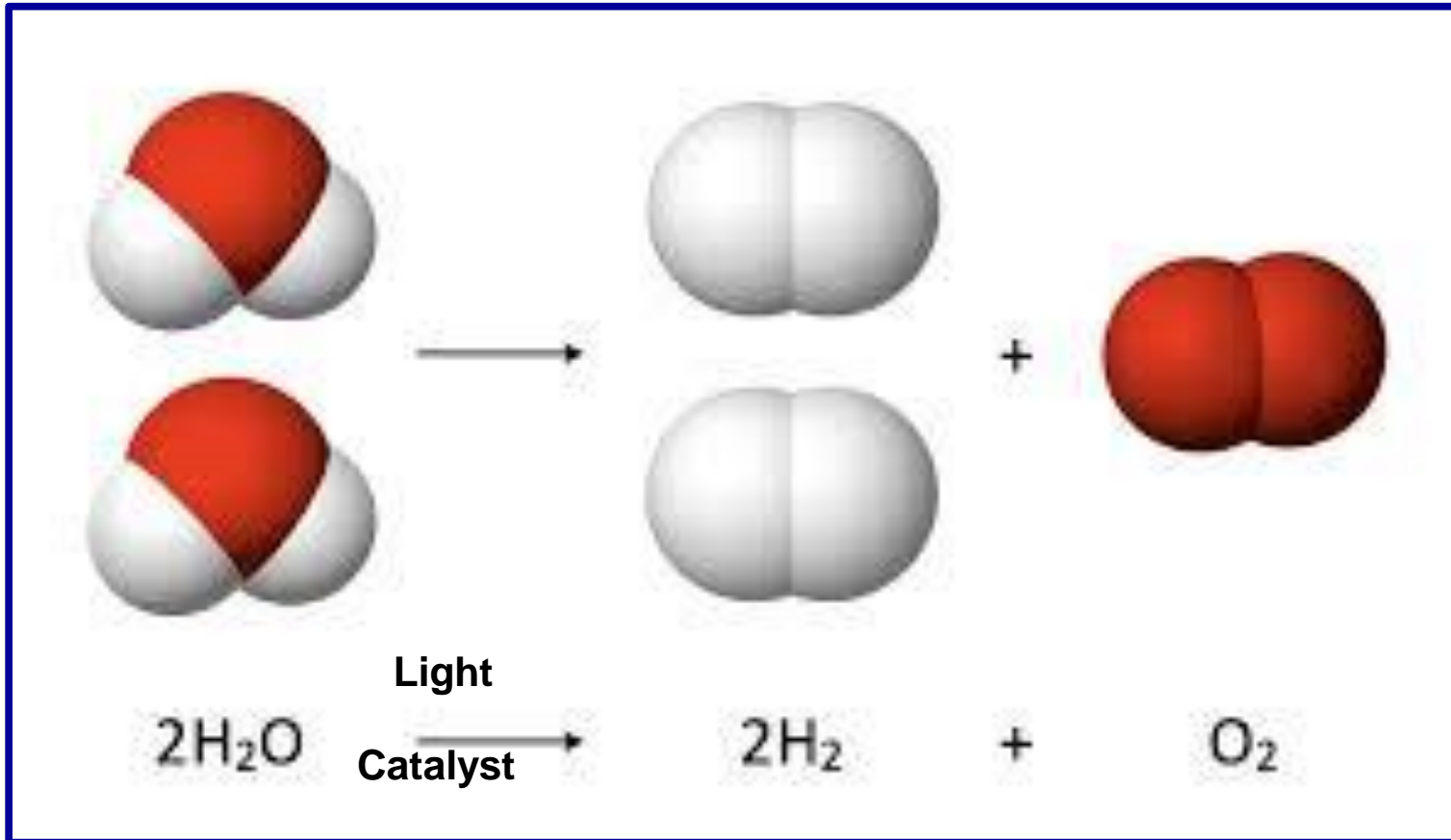


**Design Cheap Catalysts!**  
**Solve Water and Energy Problems!**

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# H<sub>2</sub> from Splitting Water



**Design Cheap Catalysts!  
Solve Water and Energy Problems!**

# First: Understand How Platinum Works

## PERIODIC TABLE Atomic Properties of the Elements

**NIST**  
National Institute of  
Standards and Technology  
U.S. Department of Commerce

**Frequently used fundamental physical constants**  
For the most accurate values of these and other constants, visit [physics.nist.gov/constants](http://physics.nist.gov/constants)  
1 second = 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of  $^{133}\text{Cs}$

speed of light in vacuum	$c$	299 792 458	$\text{m s}^{-1}$	(exact)
Planck constant	$h$	6,6261 x 10 <sup>-34</sup>	J s	( $\hbar = h/2\pi$ )
elementary charge	$e$	1,6022 x 10 <sup>-19</sup>	C	
electron mass	$m_e$	9,1094 x 10 <sup>-31</sup>	kg	
	$m_e c^2$	0,5110	MeV	
proton mass	$m_p$	1,6726 x 10 <sup>-27</sup>	kg	
fine-structure constant	$\alpha$	1/137,036		
Rydberg constant	$R_\infty$	10 973 732	$\text{m}^{-1}$	
	$R_\infty c$	3,289 842 x 10 <sup>15</sup>	Hz	
	$R_\infty hc$	13,6057	eV	
Boltzmann constant	$k$	1,3807 x 10 <sup>-23</sup>	J K <sup>-1</sup>	

- Solids
- Liquids
- Gases
- Artificially Prepared

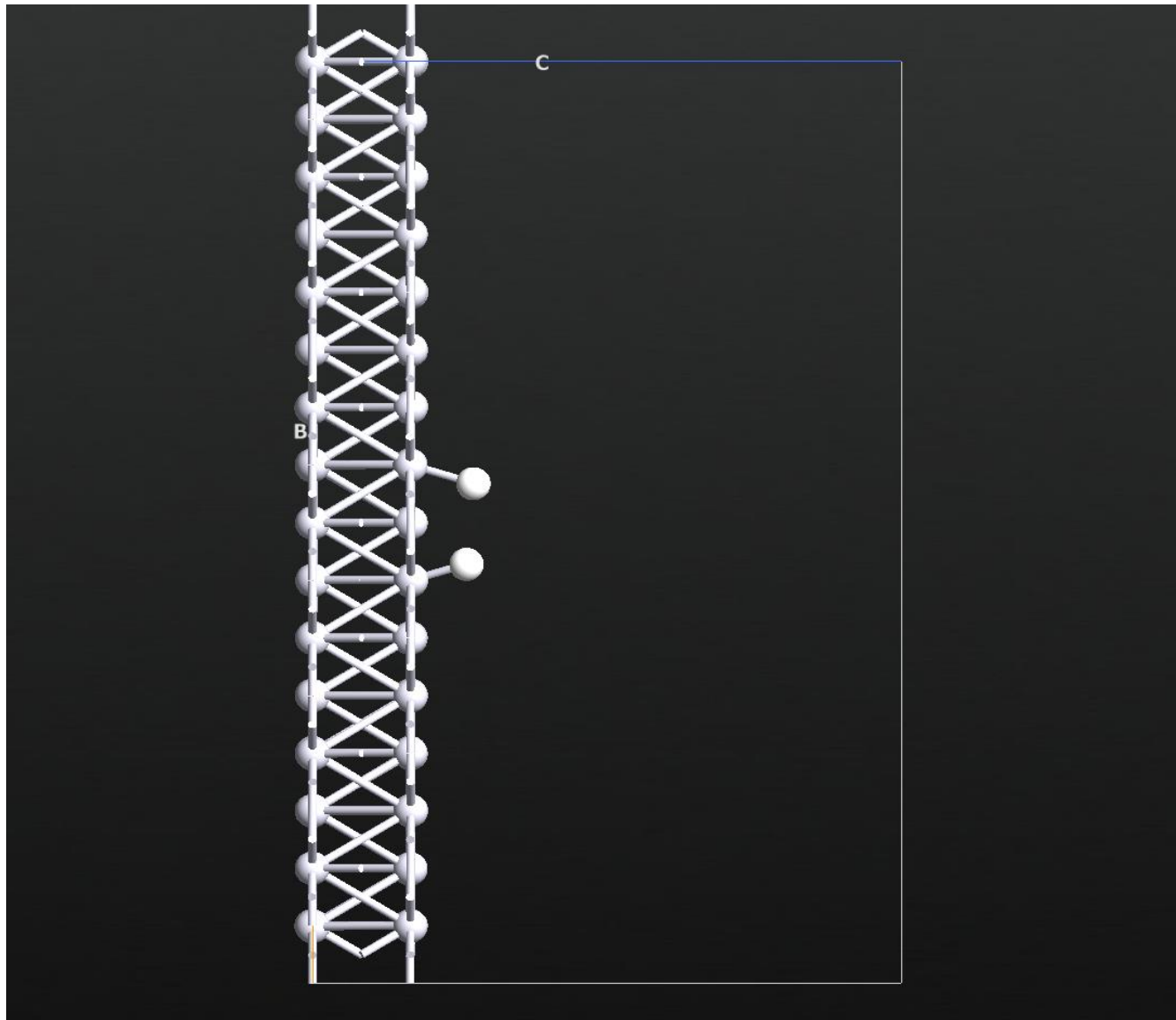
Physics Laboratory <a href="http://physics.nist.gov">physics.nist.gov</a>		Standard Reference Data <a href="http://www.nist.gov/srd">www.nist.gov/srd</a>			
13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
5 B Boron 10,811 1s <sup>2</sup> 2s <sup>2</sup> 2p 8,2980	6 C Carbon 12,0107 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>2</sup> 11,2603	7 N Nitrogen 14,0067 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>3</sup> 14,5341	8 O Oxygen 15,9994 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>4</sup> 13,0181	9 F Fluorine 18,9984032 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>5</sup> 17,4228	10 Ne Neon 20,1797 1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup> 21,5645
13 Al Aluminum 26,9815386 [Ne]3s <sup>2</sup> 3p 5,9858	14 Si Silicon 28,0855 [Ne]3s <sup>2</sup> 3p <sup>2</sup> 8,1517	15 P Phosphorus 30,973762 [Ne]3s <sup>2</sup> 3p <sup>3</sup> 10,4867	16 S Sulfur 32,065 [Ne]3s <sup>2</sup> 3p <sup>4</sup> 10,3600	17 Cl Chlorine 35,453 [Ne]3s <sup>2</sup> 3p <sup>5</sup> 12,9676	18 Ar Argon 39,948 [Ne]3s <sup>2</sup> 3p <sup>6</sup> 15,7595
31 Ga Gallium 69,723 [Ar]3d <sup>10</sup> 4s <sup>2</sup> 4p 5,9993	32 Ge Germanium 72,64 [Ar]3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>2</sup> 7,8994	33 As Arsenic 74,92160 [Ar]3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>3</sup> 9,7886	34 Se Selenium 78,96 [Ar]3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>4</sup> 9,7524	35 Br Bromine 79,904 [Ar]3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>5</sup> 11,8138	36 Kr Krypton 83,798 [Ar]3d <sup>10</sup> 4s <sup>2</sup> 4p <sup>6</sup> 13,9996
49 In Indium 114,916 [Kr]4d <sup>10</sup> 5s <sup>2</sup> 5p 5,7884	50 Sn Tin 118,710 [Kr]4d <sup>10</sup> 5s <sup>2</sup> 5p <sup>2</sup> 7,3439	51 Sb Antimony 121,760 [Kr]4d <sup>10</sup> 5s <sup>2</sup> 5p <sup>3</sup> 8,6084	52 Te Tellurium 127,60 [Kr]4d <sup>10</sup> 5s <sup>2</sup> 5p <sup>4</sup> 9,0098	53 I Iodine 126,90447 [Kr]4d <sup>10</sup> 5s <sup>2</sup> 5p <sup>5</sup> 10,4513	54 Xe Xenon 131,293 [Kr]4d <sup>10</sup> 5s <sup>2</sup> 5p <sup>6</sup> 12,1298
80 Hg Mercury 200,59 10,4375	81 Tl Thallium 204,3833 [Hg]6p 6,1082	82 Pb Lead 207,2 [Hg]6p <sup>2</sup> 7,4167	83 Bi Bismuth 208,98040 [Hg]6p <sup>3</sup> 7,2855	84 Po Polonium (209) [Hg]6p <sup>4</sup> 8,414	85 At Astatine (210) [Hg]6p <sup>5</sup> 10,7485
80 Hg Mercury 200,59 10,4375	81 Tl Thallium 204,3833 [Hg]6p 6,1082	82 Pb Lead 207,2 [Hg]6p <sup>2</sup> 7,4167	83 Bi Bismuth 208,98040 [Hg]6p <sup>3</sup> 7,2855	84 Po Polonium (209) [Hg]6p <sup>4</sup> 8,414	85 At Astatine (210) [Hg]6p <sup>5</sup> 10,7485

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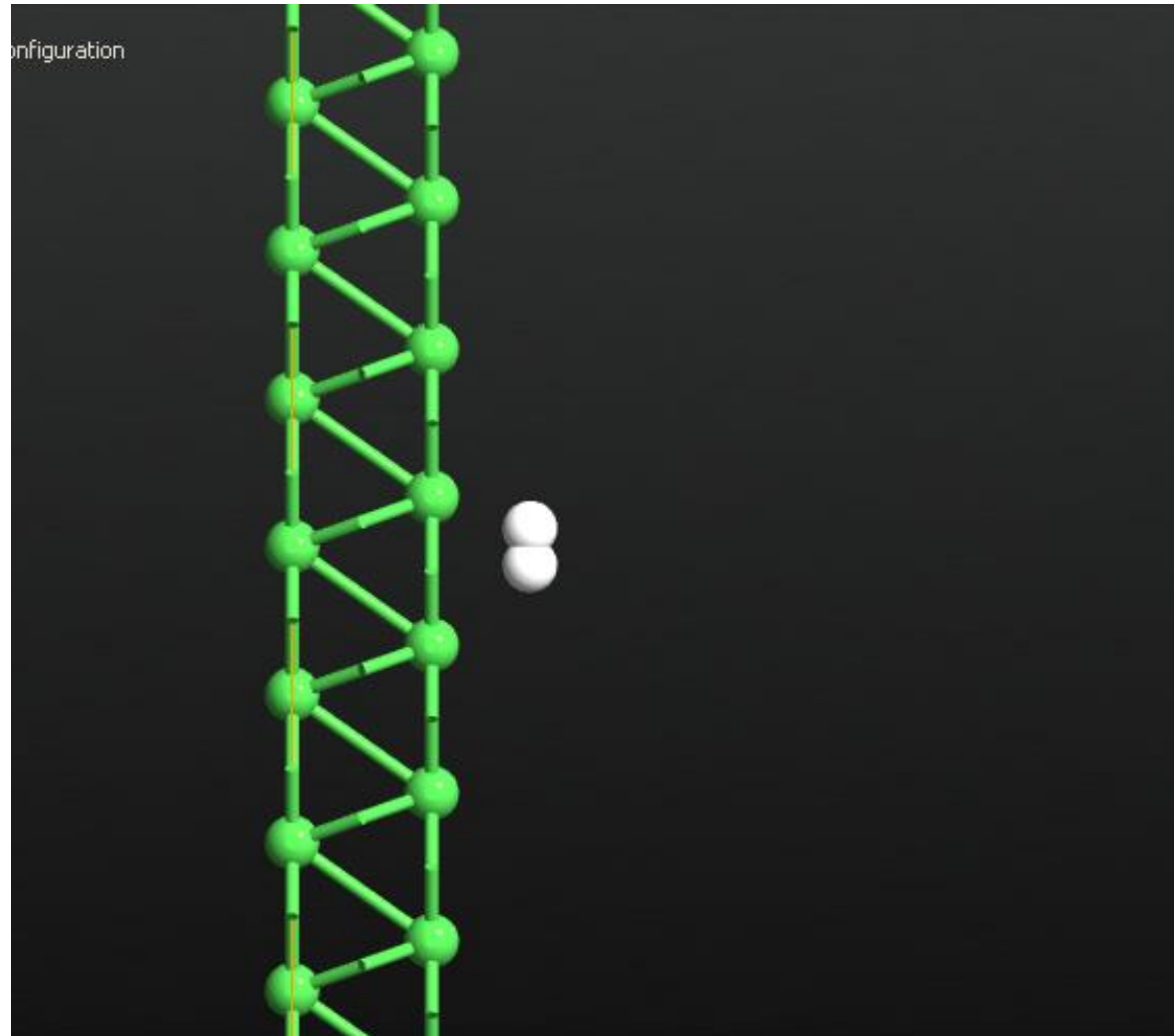
# First: Understand How Platinum Works



**H<sub>2</sub>  
on  
PLATINUM**

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# First: Understand How Platinum Works



H<sub>2</sub>  
on  
NICKEL

*...Research and Discoveries for African Development and Advancement*

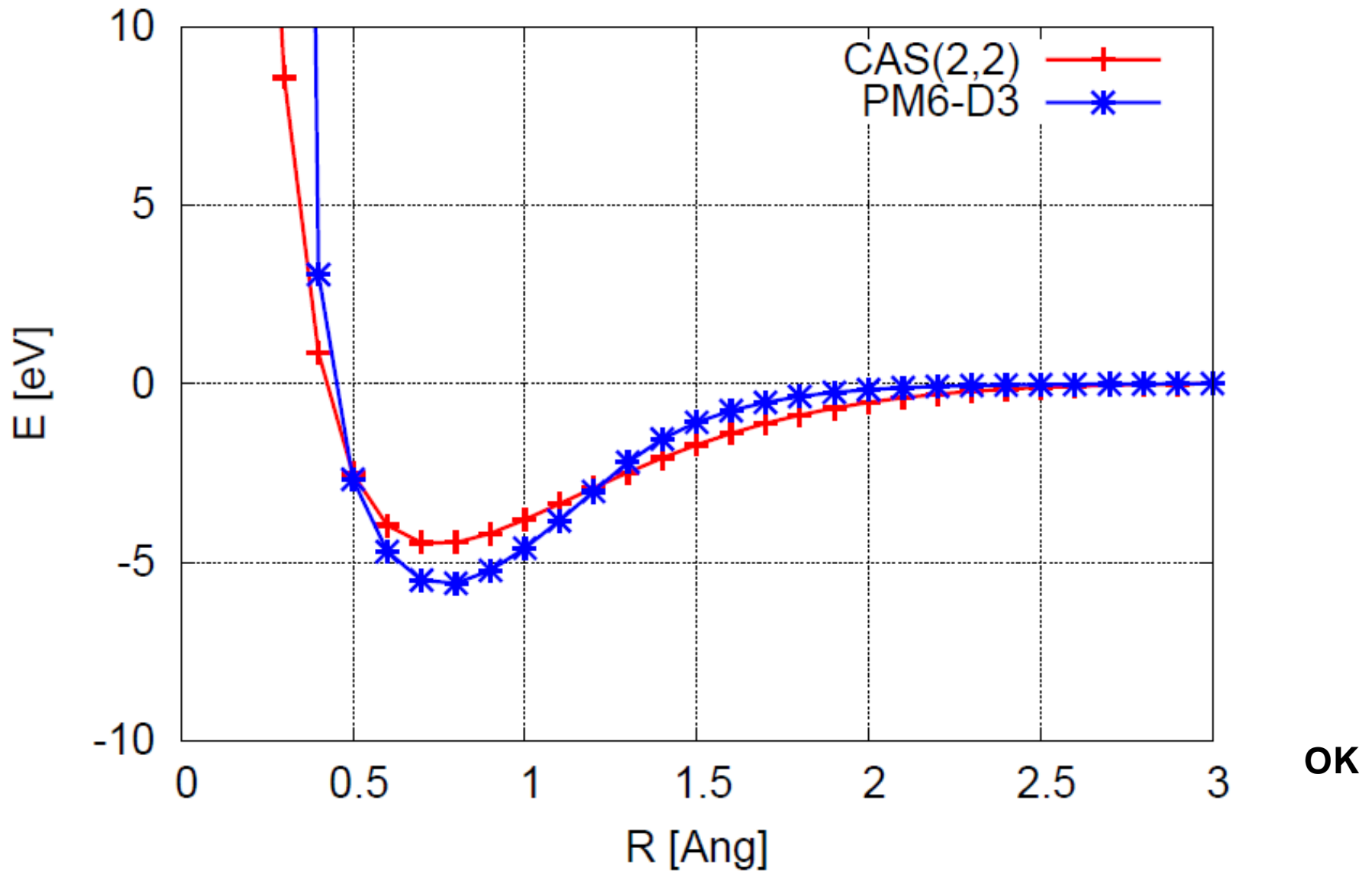


# First: Understand How Platinum Works

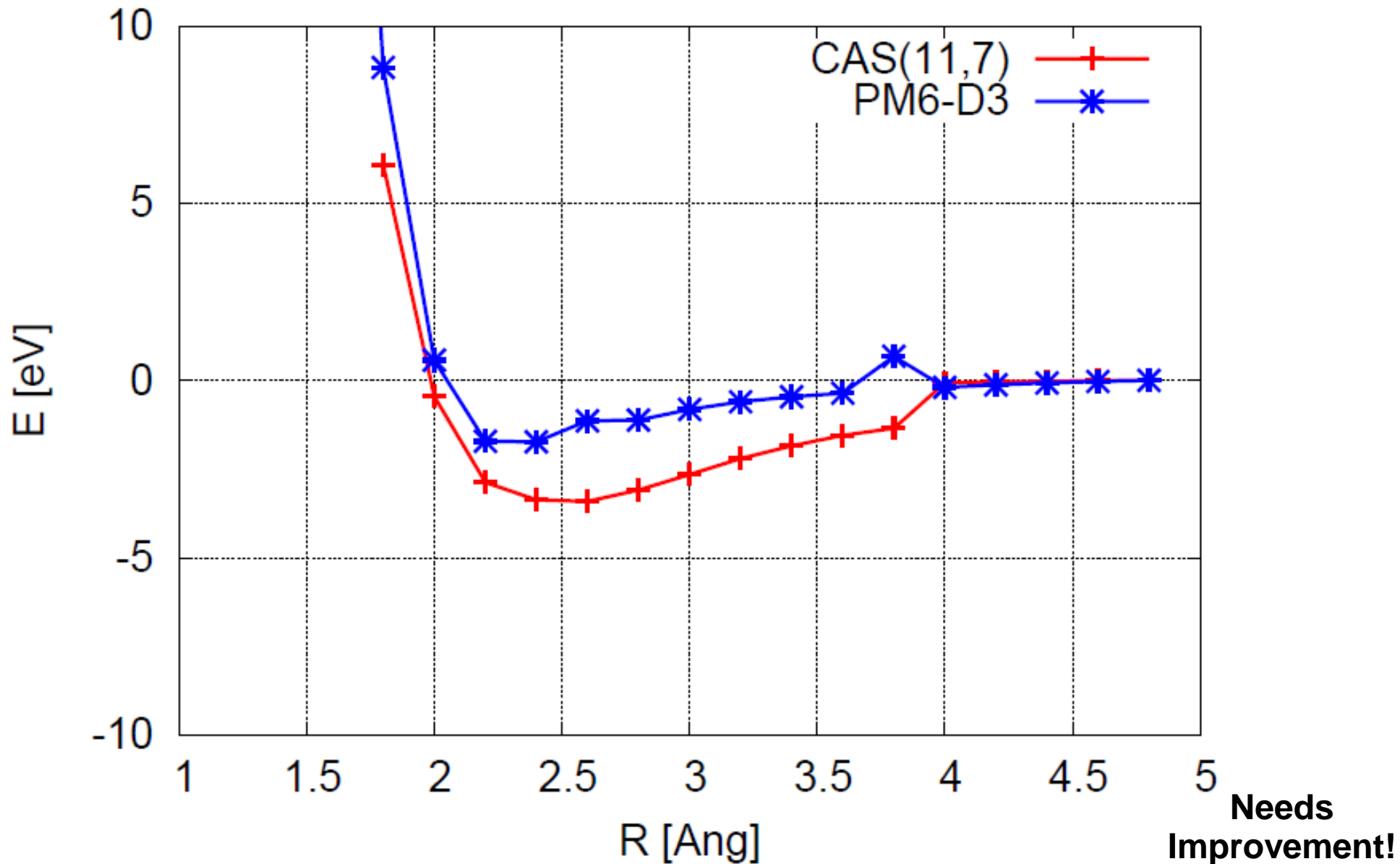
## Probing by Molecular Dynamic Simulations

- 1) Differences in Structure?
- 2) Differences in Energy?
- 3) Differences in Charge Transfer: Use DFT or SEMD

# SEMD Forces: H-H



# SEMD Forces: Pt-Pt



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# PhD Program



## By Research:

- 
- (1) Find suitable supervisors and co-supervisors
  - (2) Determine area(s) of common interests and develop a research proposal
  - (3) Apply through Univ. of Rwanda (UR)
  - (4) ~ \$2,000 tuition per year  
+ ~ \$8,000 per year for support
  - (5) Begin research
  - (6) Pass the 'Qualifier' Exams
  - (7) Continue: Research, Papers, Defend, Graduate

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# MSc Program: 2-yr

## By Research:

(1) Apply online

(2) < Selection >

(3) ~ \$2,000 tuition per year

+ ~ \$8,000 per year for support

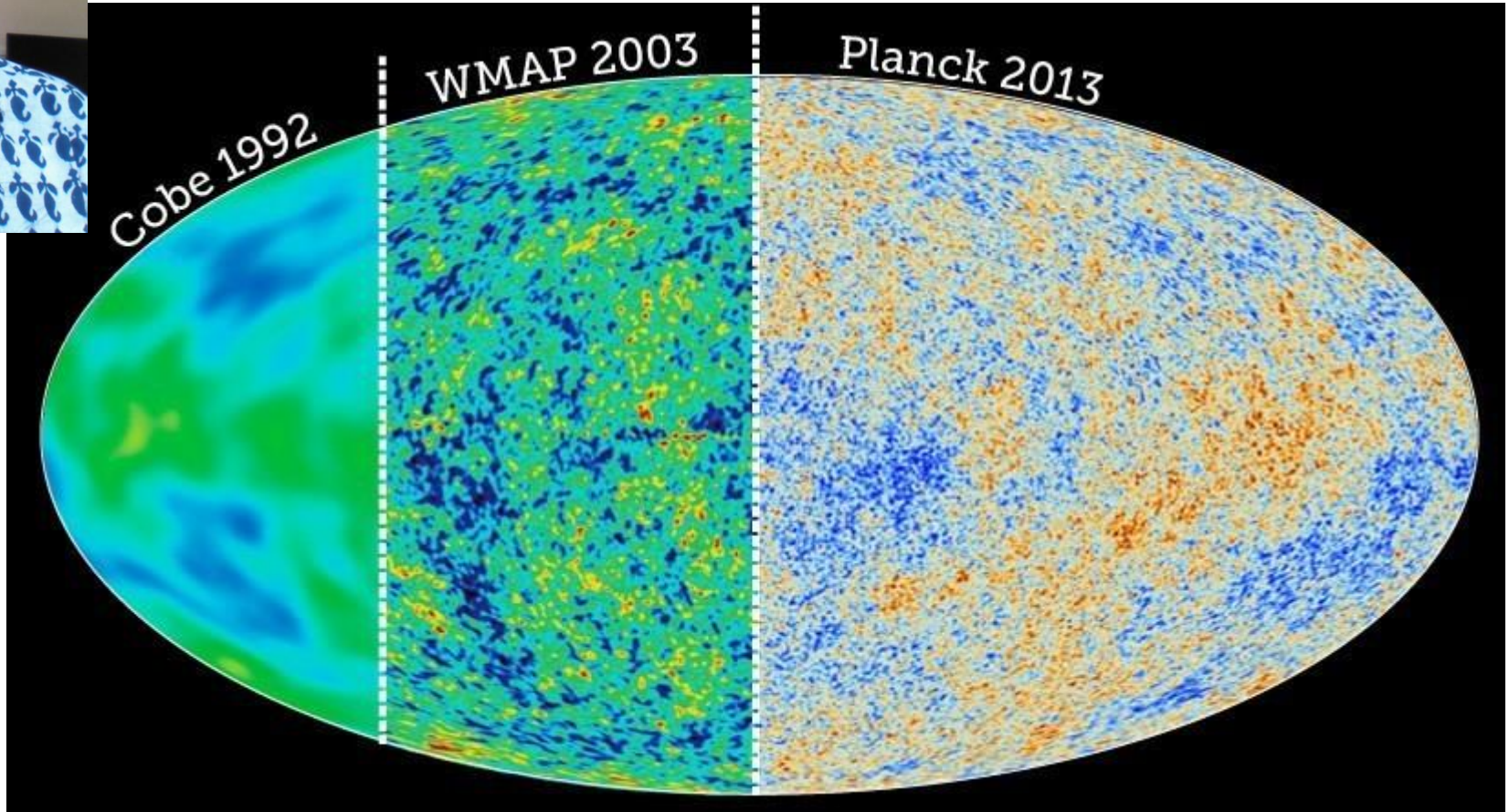
(4) 1<sup>st</sup> Year: BASIC PHYSICS (Revamp of Undergrad)

(5) 2<sup>nd</sup> Year: Specialize

- High Energy Physics
- Condensed Matter Physics
- Solid Earth Physics (Geophysics)

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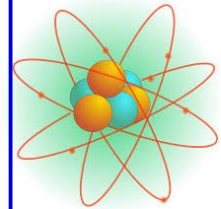
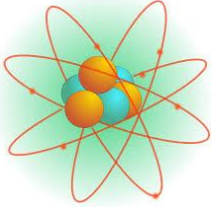
# The origins of the Universe



Cosmic Microwave radiation, released when the Universe is very young.  
It has small temperature fluctuations of  $1/10.000$ .  
It is used to infer the initial conditions of the Universe.

# PROGRESS

[And Future: 2017, 2018, ...]



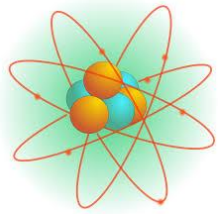
## **2017:**

- \* **Four (4) Seminars (Sept – Dec)**
- \* **Hirings (Two scientists)**

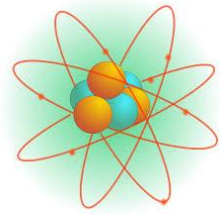
## **2018:**

- \* **Three Short Courses**
  - June/July: SCITAP (Solar Cells In Theory And Practice)**
- \* **Three Workshops**
  - May: IEEE Entrepreneurship Workshop**
  - Oct: Women In Science**
  - Oct: CODATA**
- \* **MSc students start in September**
- \* **INAUGURATION in October**
- \* **More hirings:**
  - Two/Three scientists,**
  - Two Admin. Assts.**
  - One IT**

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# EAIFR



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and  
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(RADADA)*