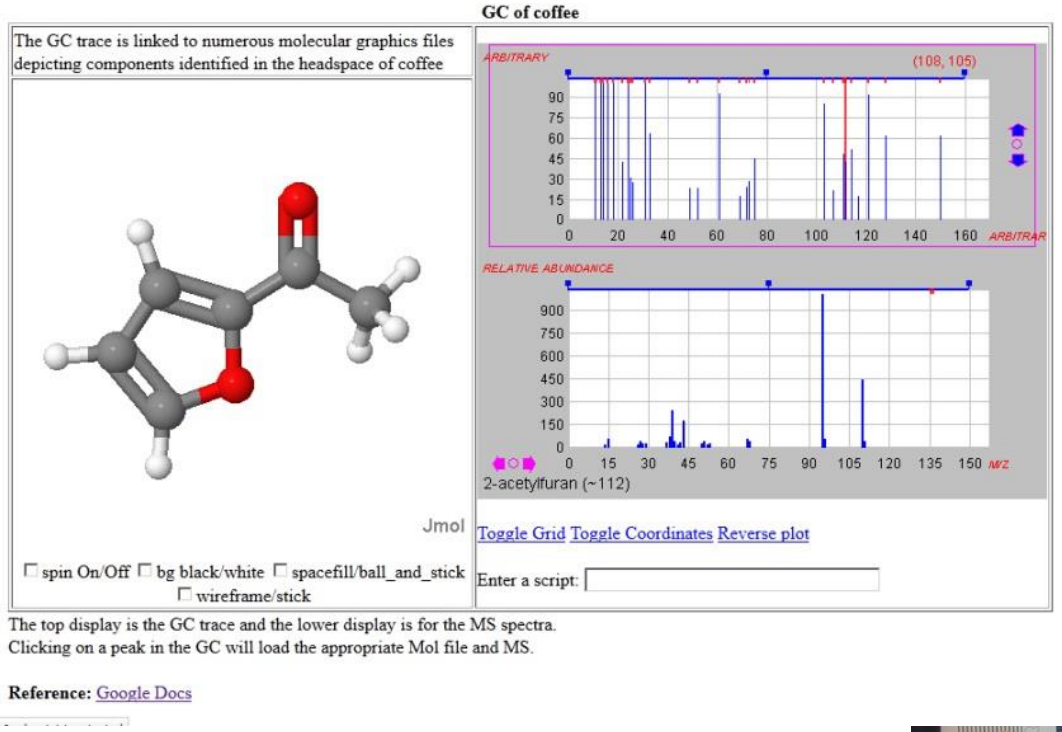
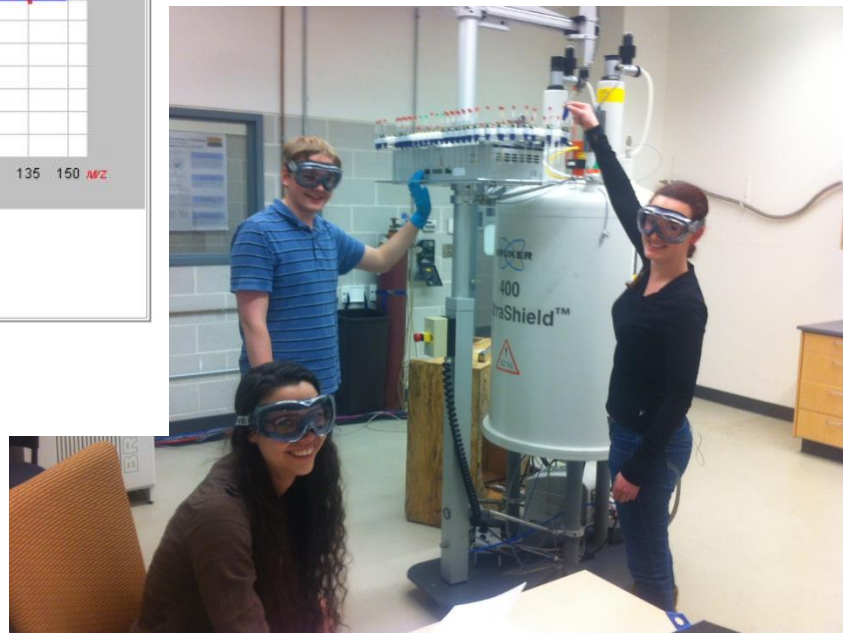
SwingJS -- Resurrecting the interactive functionality of Java on the web as JavaScript

Bob Hanson
Department of Chemistry
St. Olaf College





MSCS Colloquium
St. Olaf College
April 15, 2019

Acknowledgments

Summer, 2016

Nadia El Mouldi

Andreas Raduege

Acknowledgments

Summer, 2017

Andrew Lee

Tahir Ahsan

Nikesh Yadav

Acknowledgments

early SwingJS collaborators

Zhou Renjian

Shanghai, China

Paul Falstad

Minneapolis, MN

Udo Borkowski

Aachen, Germany

Outline of presentation

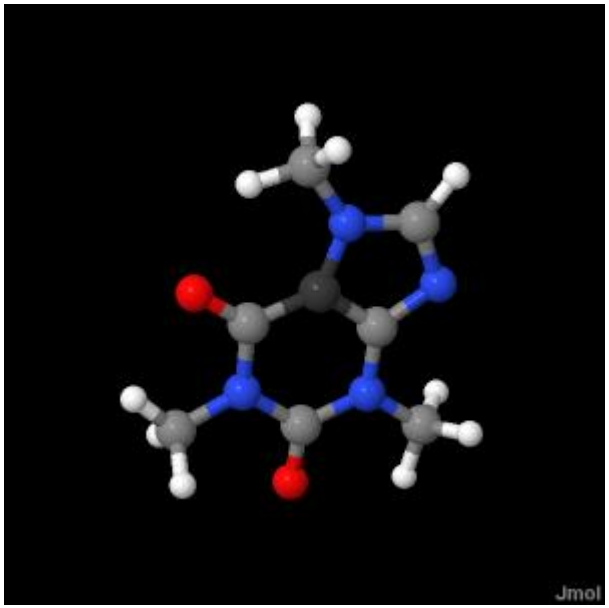
Historical context

The problem and its solution

Where we are now

Where we are headed

Jmol



Mission: The high-quality, real-time visualization of molecular structure, dynamics, and energetics.

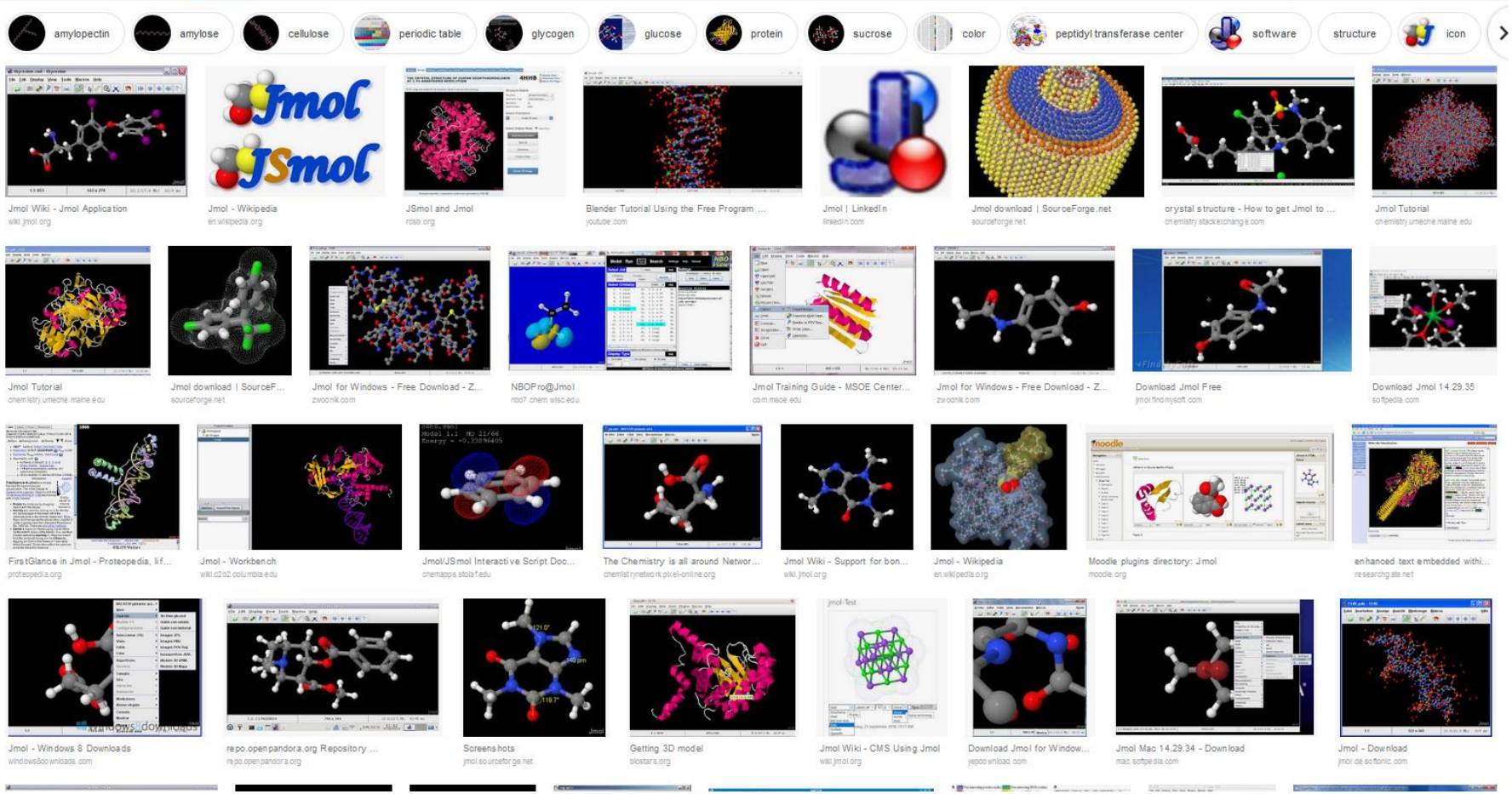
open source Java

cross-disciplinary

development driven by user input

Principal developer since 2006

Jmol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glycogen
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protein
sucrose
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peptidyl transferase center
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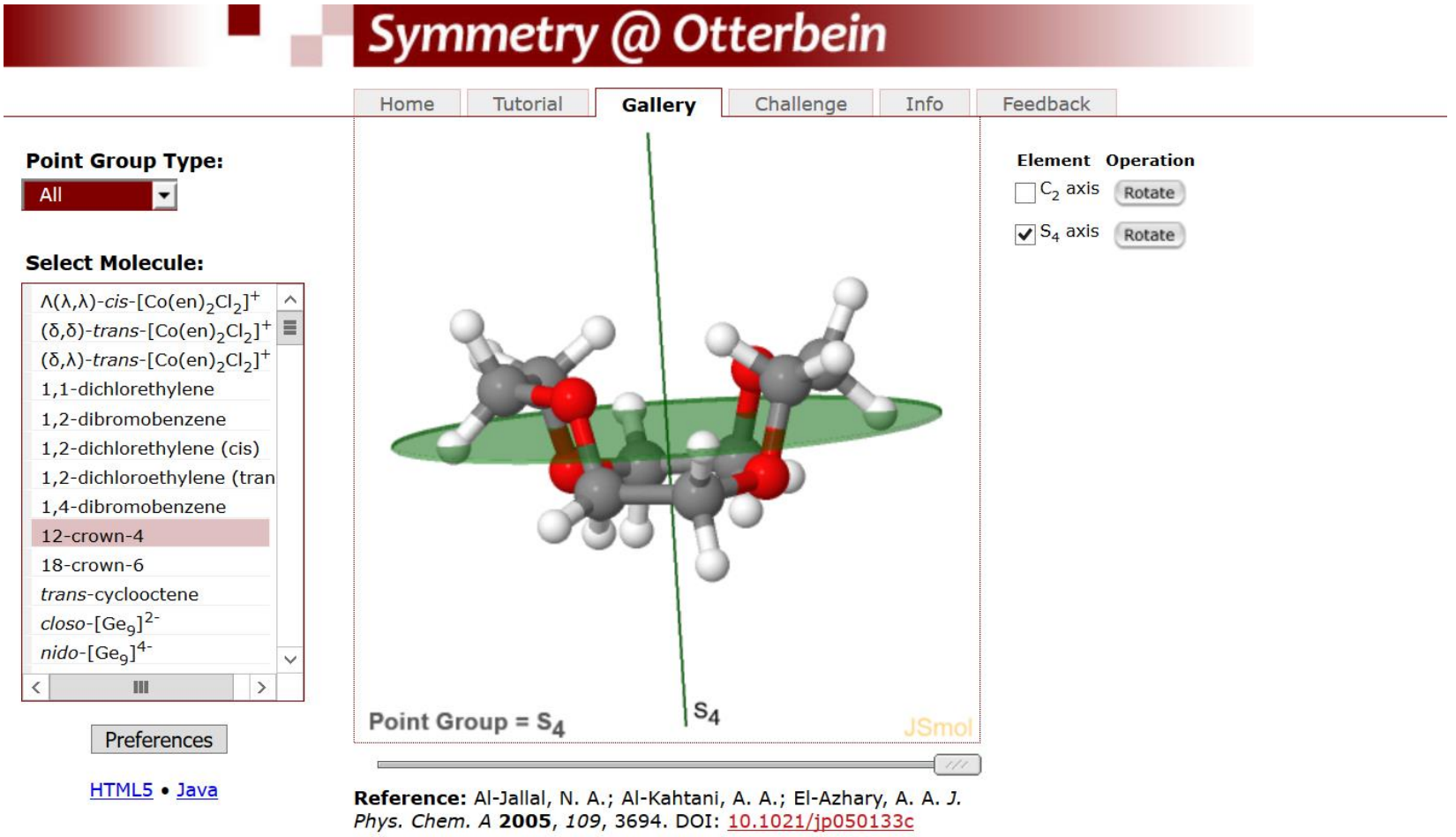
jmol.de.softonic.com

Demo Jmol and Jspecview

https://chemapps.stolaf.edu/jmol/jsmol/simple2.htm

https://chemapps.stolaf.edu/jmol/jsmol/nmr_predict_1H.htm

Jmol

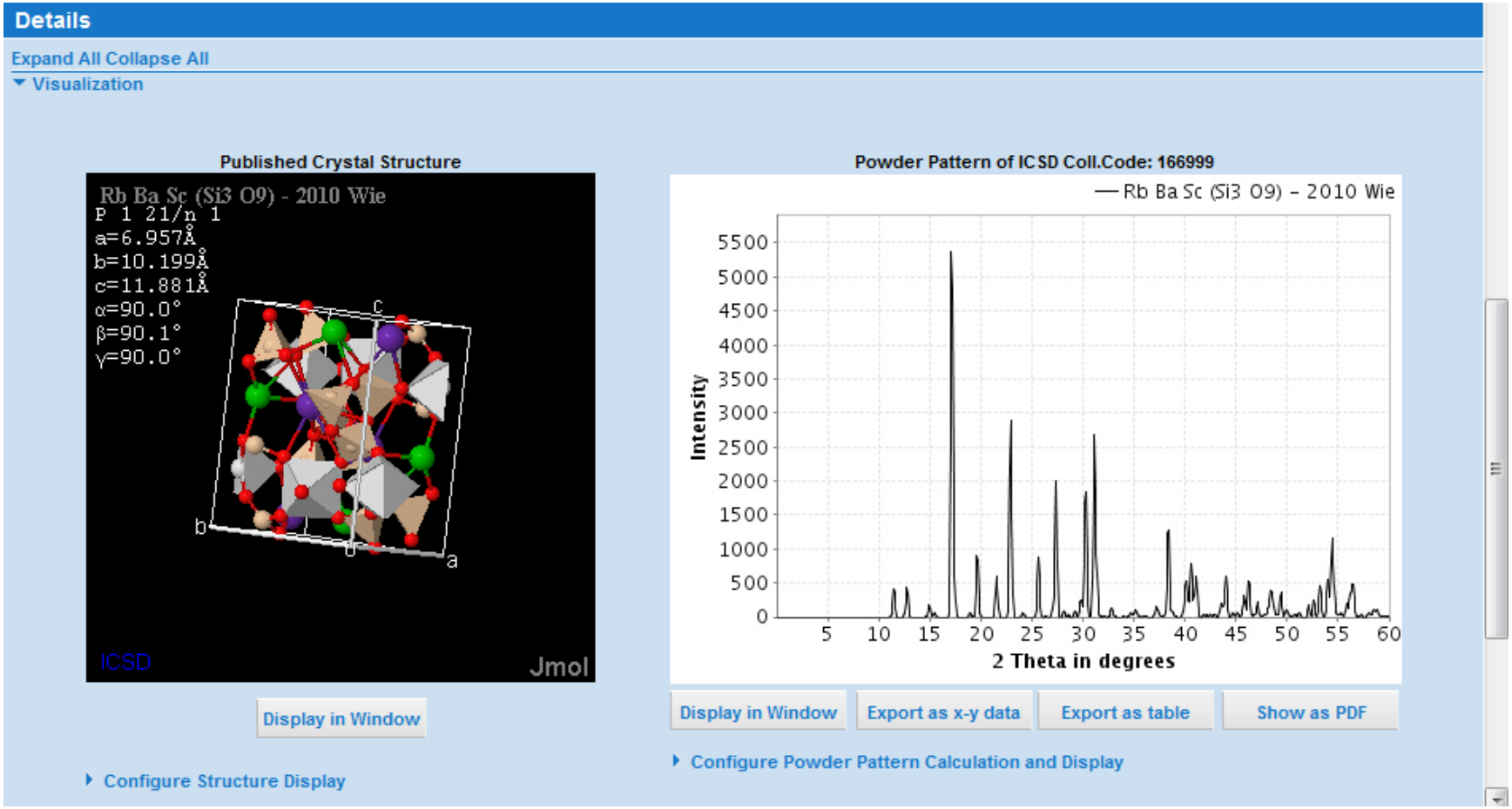


Dean Johnston http://symmetry.otterbein.edu/gallery/

Demo Otterbein Symmetry Gallery

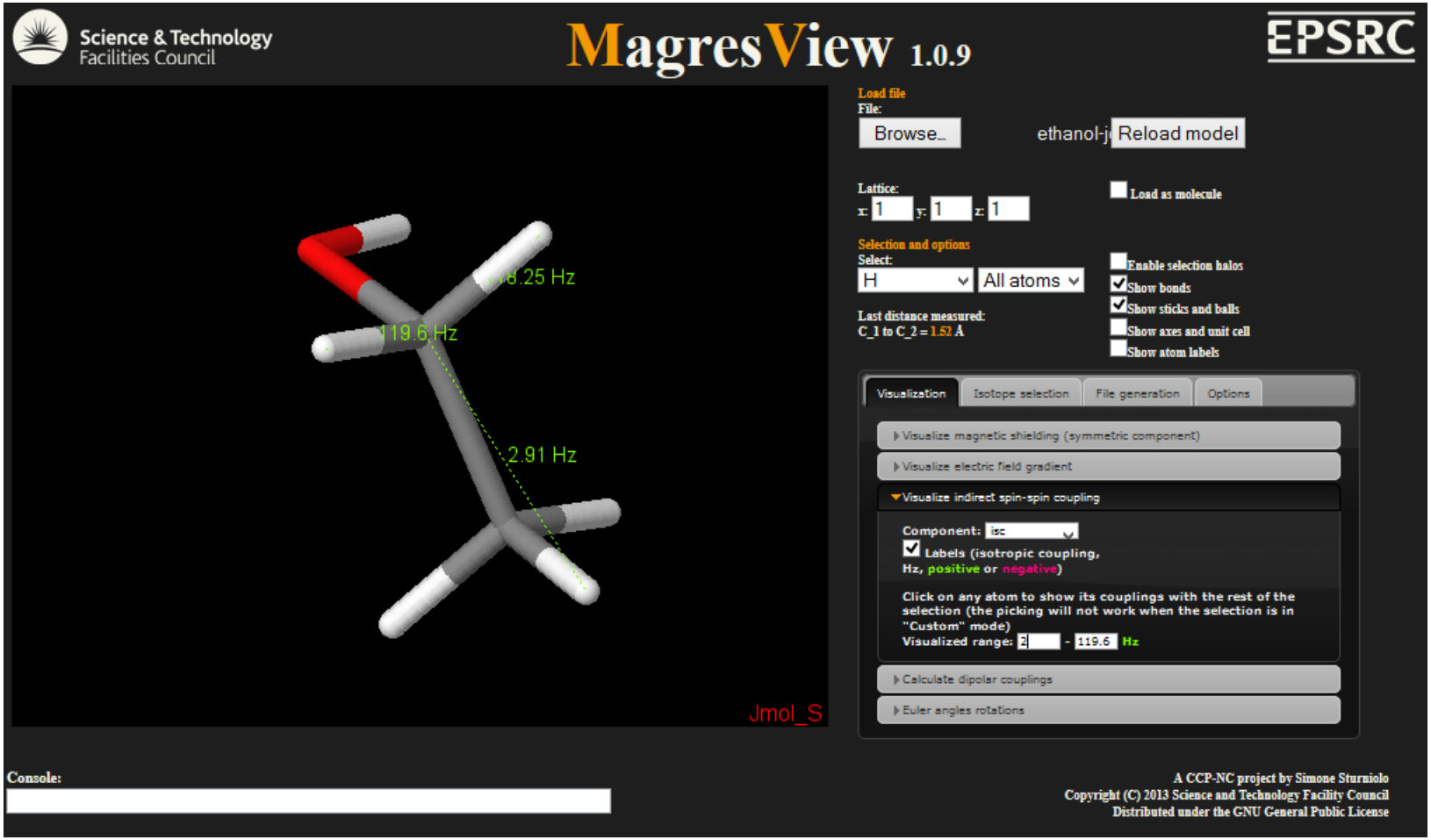
http://symmetry.otterbein.edu/gallery/

Jmol



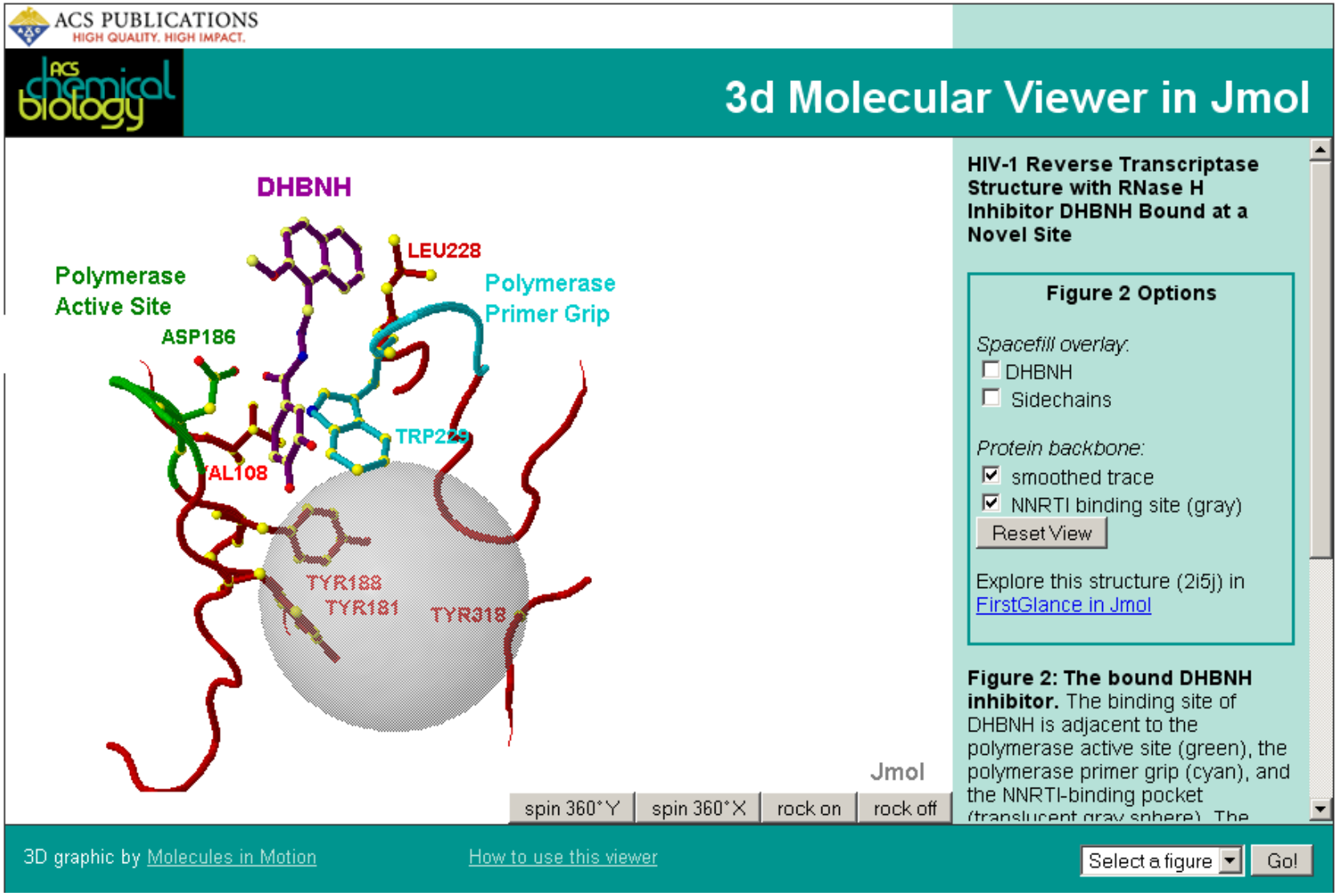
Inorganic Crystal Structure Database http://icsd.ill.fr/icsd/index.html

Jmol



Simone Sturniolo and Jonathan Yates, Department of Materials, University of Oxford
https://www.ccpnc.ac.uk/magresview/magresview/magres_view.html

Jmol



Frieda Reichsman, http://pubs.acs.org/doi/media/10.1021/cb600303y/figure2.htm

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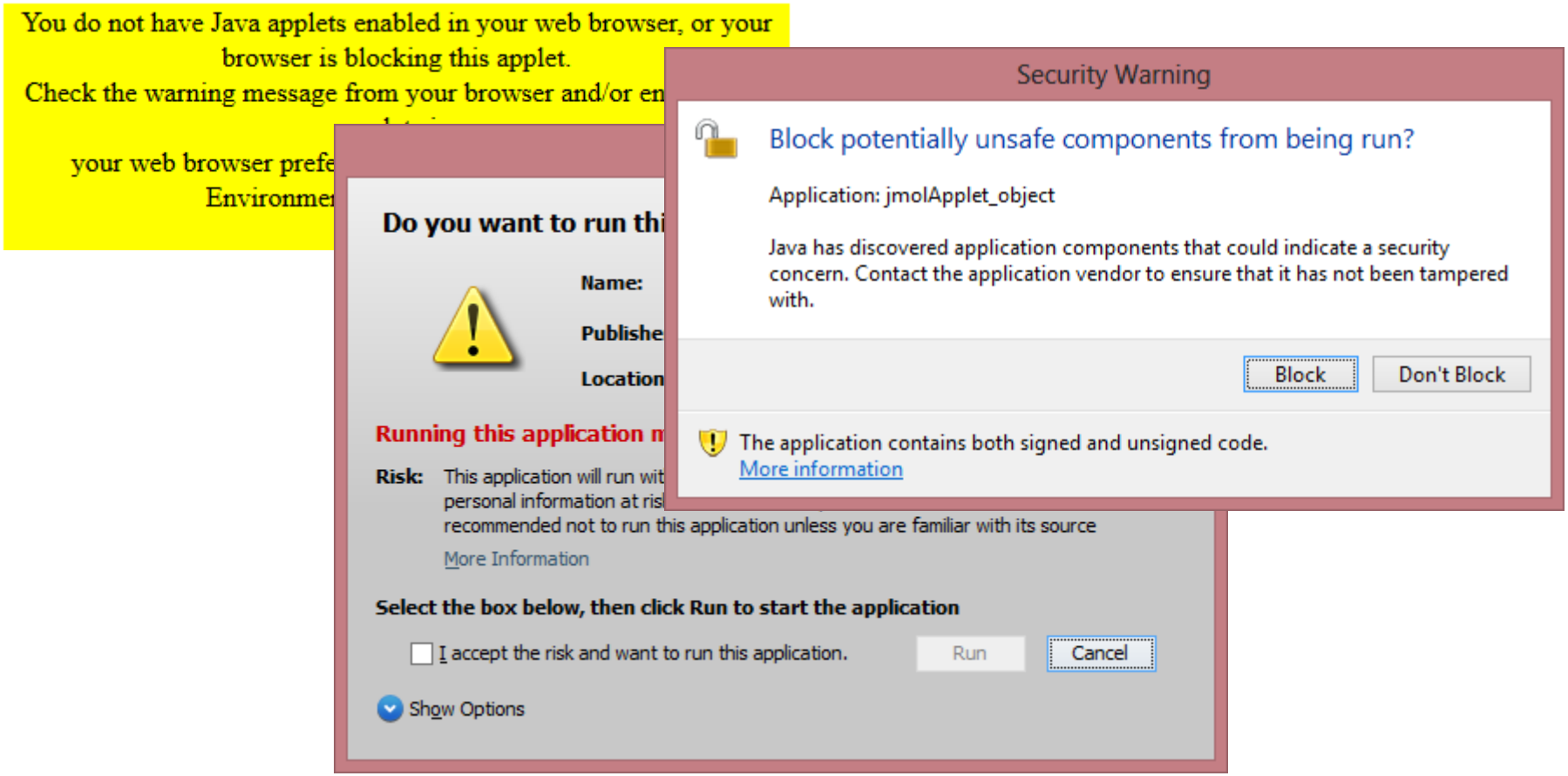
Death of the Java applet

During the summer of 2012 it became apparent that Java applets were no longer suitable for general web use.



The Problem – Java Availability

Most notably, a series of security concerns surrounding Java applets during the fall and early winter of 2012 resulted in an announcement on Jan. 10, 2013, by the U.S. Department of Homeland Security with this suggestion:

- ***Disable Java in web browsers***
- *This and previous Java vulnerabilities have been widely targeted by attackers, and new Java vulnerabilities are likely to be discovered. To defend against this and future Java vulnerabilities,* ***consider disabling Java in web browsers until adequate updates are available****. As with any software, unnecessary features should be disabled or removed as appropriate for your environment.*

https://www.us-cert.gov/ncas/alerts/TA13-010A

java2script to the rescue!

Open-Source Plug-In for Eclipse

Works as a *transpiler* (effectively)

Allows *simultaneous co*-creation of
Java “byte code” class files and
equivalent JavaScript files

Zhou Renjian

http://j2s.sourceforge.net/

java2script to the rescue!

Open-Source Plug-In for Eclipse

Includes a purely JavaScript run-time library that emulates the Java Virtual Machine

Prototype stage of development by Zhou Renjian – just a few demo implementations – never distributed

Zhou Renjian

http://j2s.sourceforge.net/

java2script to the rescue!

Sept – Dec. 2012 “JSmol” work begins at St. Olaf

Intense Jmol implementation effort (150,000 lines of code)

Sept/Oct Collaborative development (fixing transpiler bugs!)

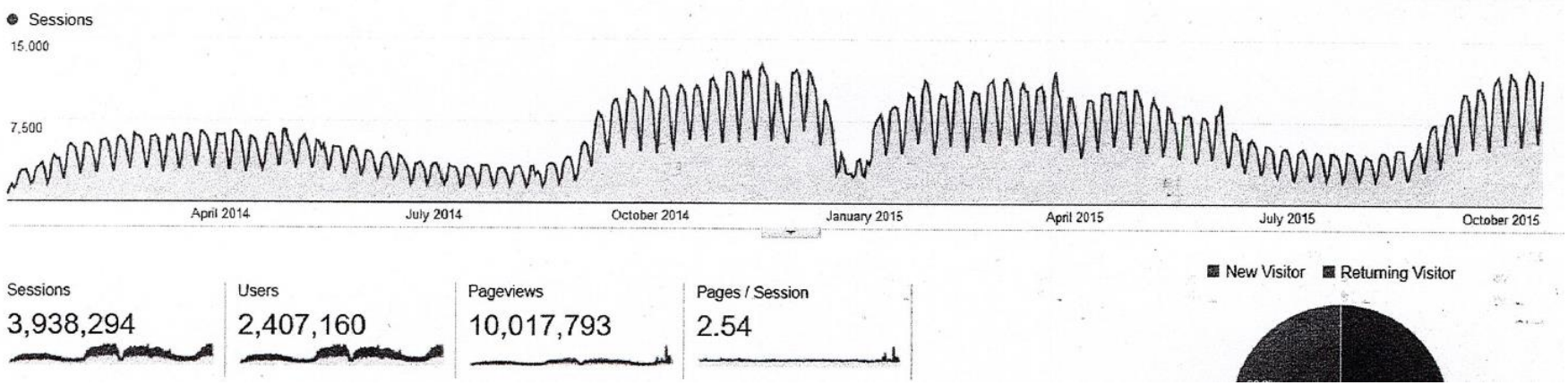
Nov/Dec Extensive Java/JavaScript performance optimization

Jan 2013 – released!

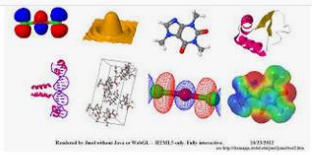
JSmol Success! 16,000+ web pages

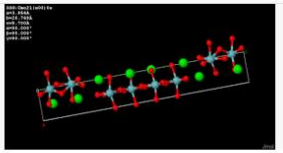
For the month of February, 2014

Jan 2014 - Oct, 2015

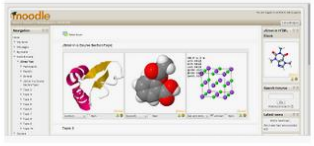


JSmol Success! 16,000+ web pages

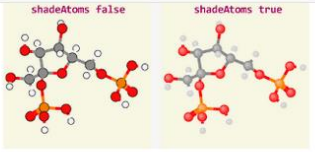

JSmol download | SourceForge.net
sourceforge.net


Index of /jmol/jsmol-2015-06-19/data
chemapps.stolaf.edu


JSmol and Jmol
rcsb.org



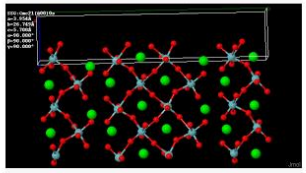
Moodle plugins directory: Jmol
moodle.org

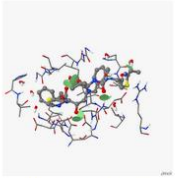


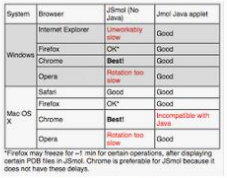
Jmol Wiki - Lightweight JSmol
wiki.jmol.org

Jmol Wiki - Jmol JavaScript Object
wiki.jmol.org

Plugins/Blocktype/Jmol - Mahara Wiki
wiki.mahara.org


JSmol -- Jmol/HTML5 Demo
chemapps.stolaf.edu

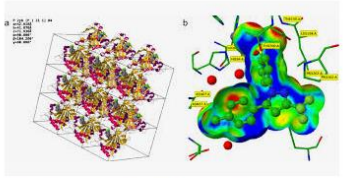

jmolApplet0 - Jmol 14.29.18
chemapps.stolaf.edu

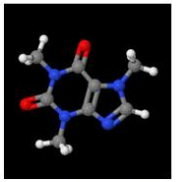


System	Browser	JSmol (No Java)	Jmol Java applet
Windows	Internet Explorer	Unworkably slow	Good
	Firefox	OK*	Good
	Chrome	Best!	Good
	Opera	Rotation too slow	Good
Mac OS X	Safari	Good	Good
	Firefox	OK*	Good
	Chrome	Best!	Incompatible with Java
	Opera	Rotation too slow	Good

*Firefox may freeze for ~1 min for certain operations, after displaying certain PDB files in JSmol. Chrome is preferable for JSmol because it does not have these delays.

Jmol Wiki - JSmol pros and cons
wiki.jmol.org


Two new custom rendering options on the ...
researchgate.net


Jmol/JSmol Interactive Scr...
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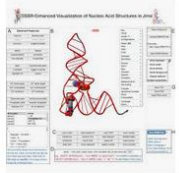
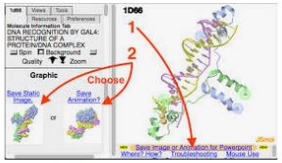
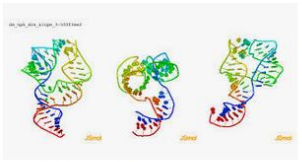

DSSR-JSmol web interfac...
researchgate.net

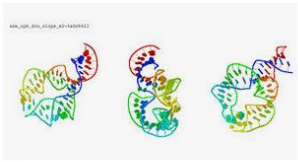
Jmol - Wikipedia
en.wikipedia.org


Using FirstGlance in JSmol - C...
sites.google.com



Versions of FirstGlance in Jmol
bioinformatics.org


JSmol - hide "JSmol" logo ...
bioinformatics.stackexchange.com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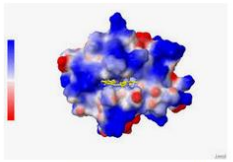
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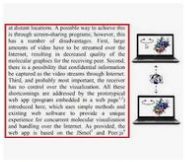
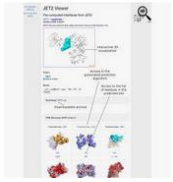
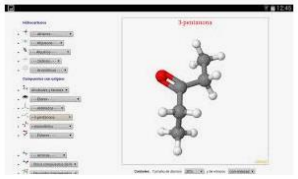
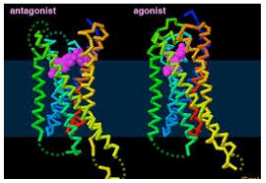
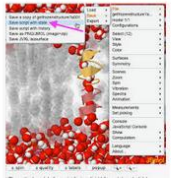
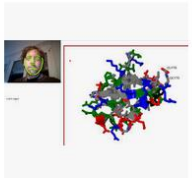

jsmol hashtag on Twitter
twitter.com



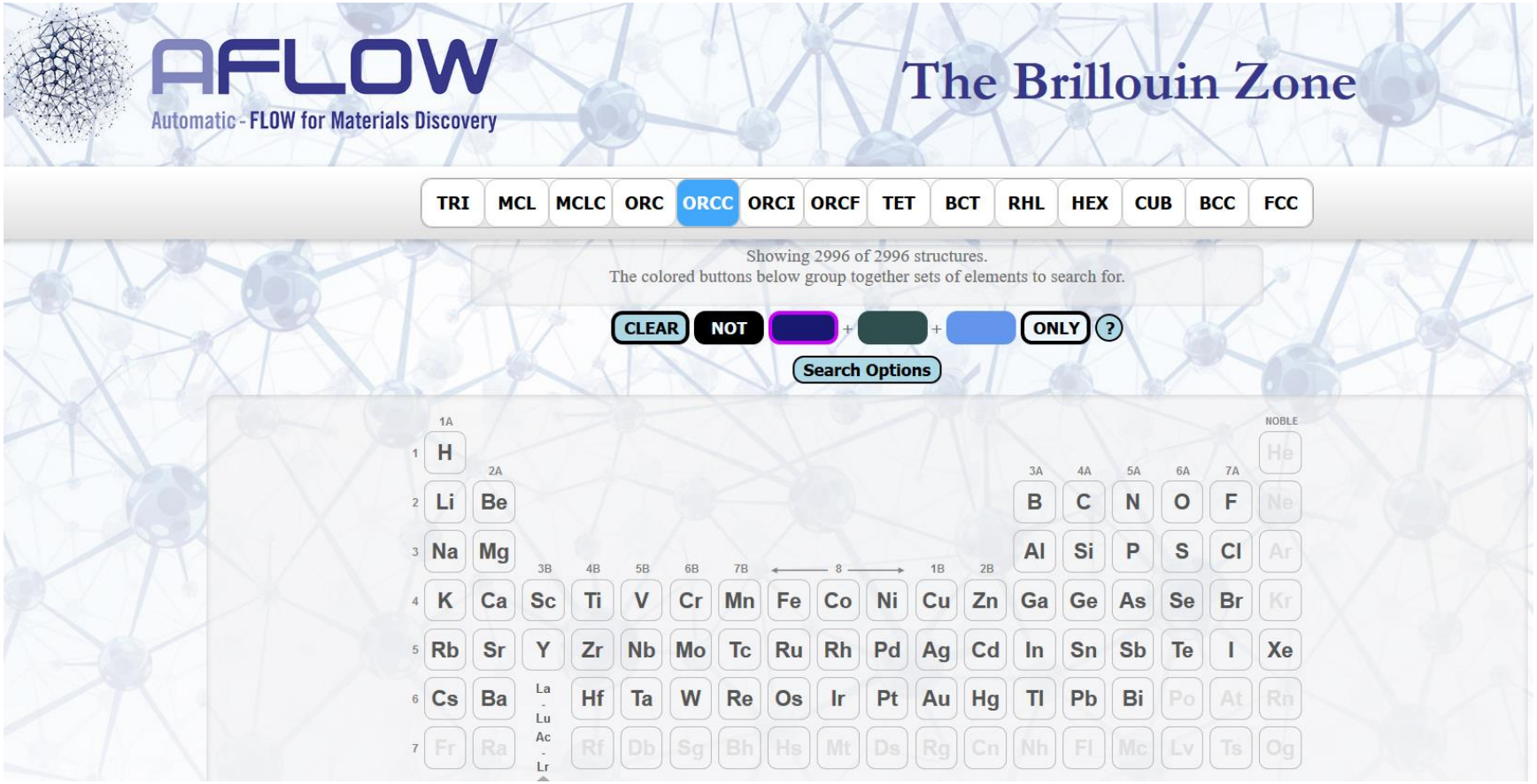








JSmol



Collaboration with Duke University and US Naval Research Laboratory

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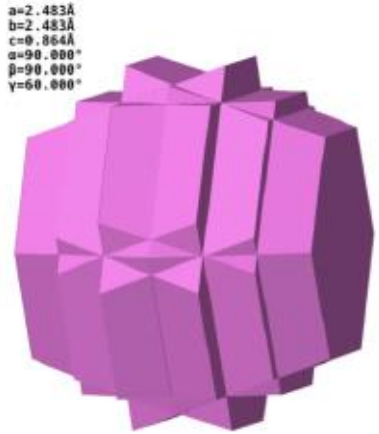

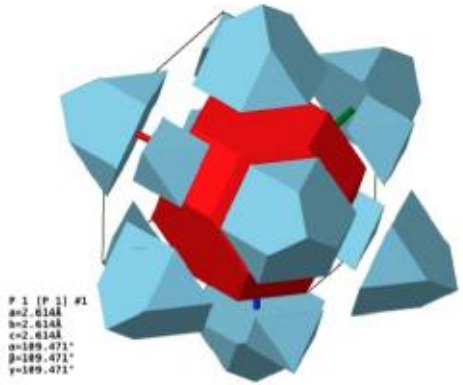

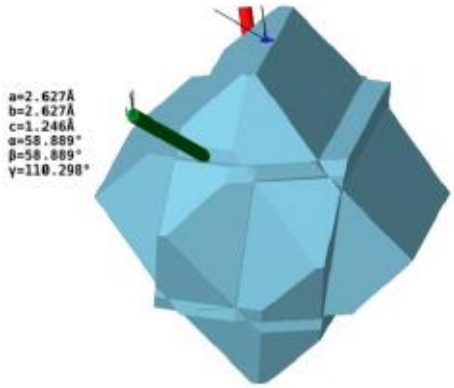

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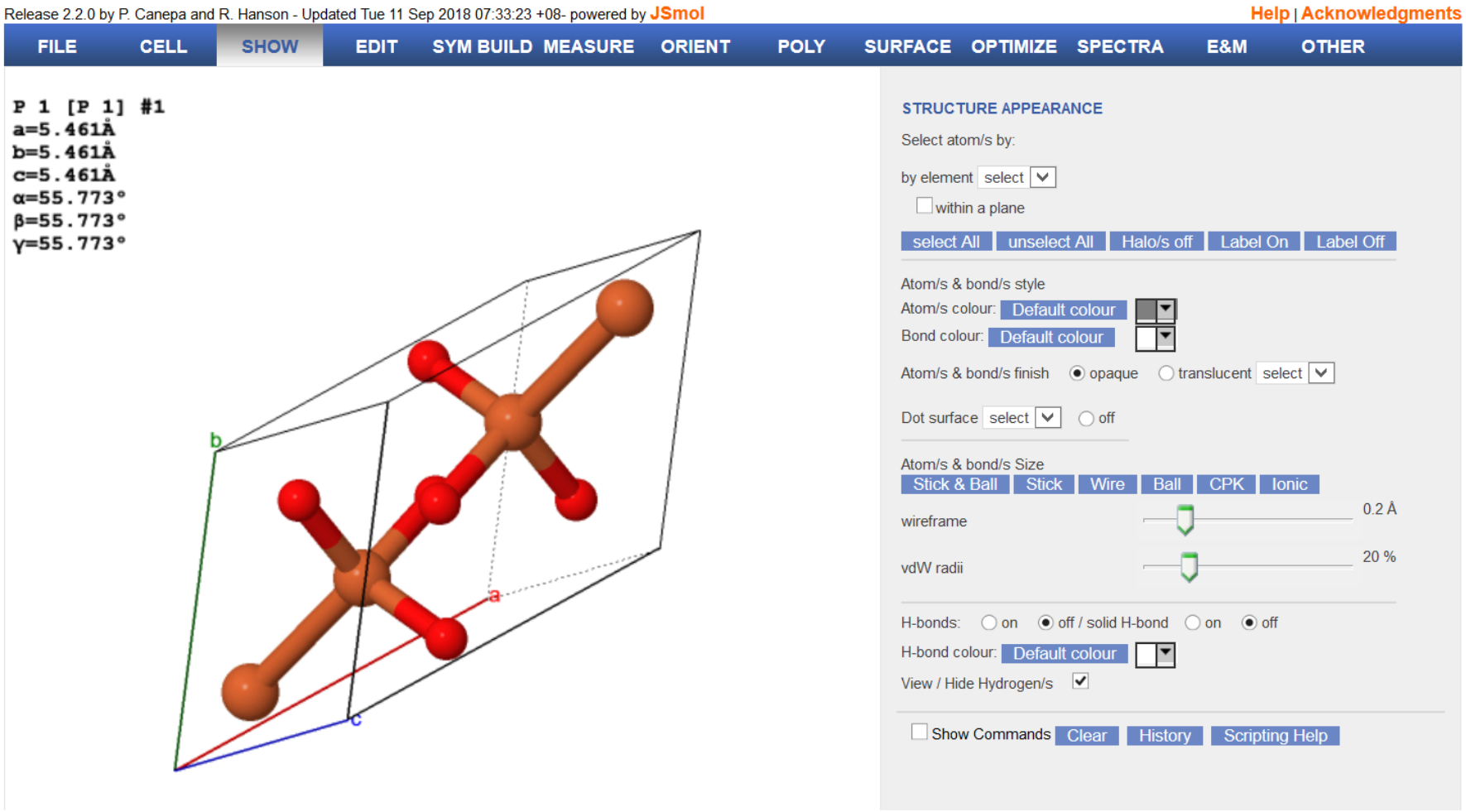


Collaboration with the University of Turin and Singapore National University

Beyond JSmol: SwingJS

Summer, 2016

Nadia El Mouldi

Andreas Raduege

Beyond JSmol: SwingJS

Summer, 2016

Q: Could this idea be generalized?

Q: Or does it end with JSmol?

Beyond JSmol: SwingJS

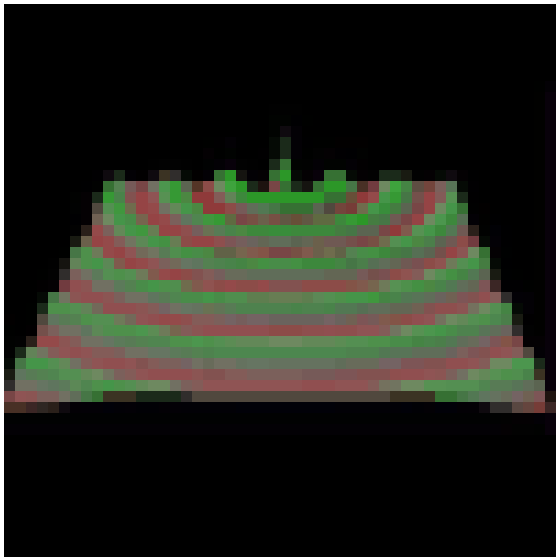
Summer, 2016

Task: Explore scope and limitations of java2script

Task: Contact possible collaborators

Task: Implement a few Java applets in JavaScript

Beyond JSmol: SwingJS



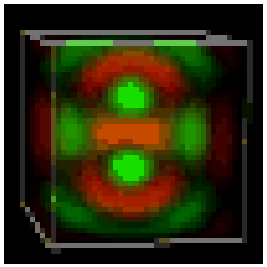
Paul Falstad

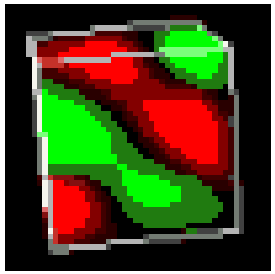
Minneapolis, MN

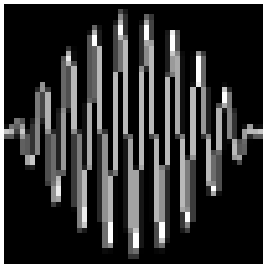
Ripple Tank (2-D Waves) Applet

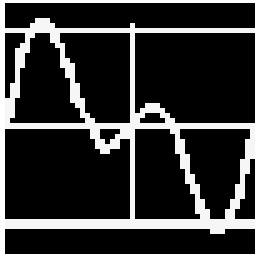
Ripple tank simulation that demonstrates wave motion, interference, diffraction, refraction, Doppler effect, etc.

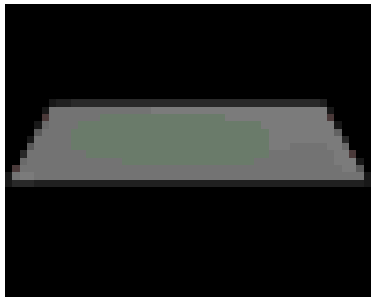
Beyond JSmol: SwingJS









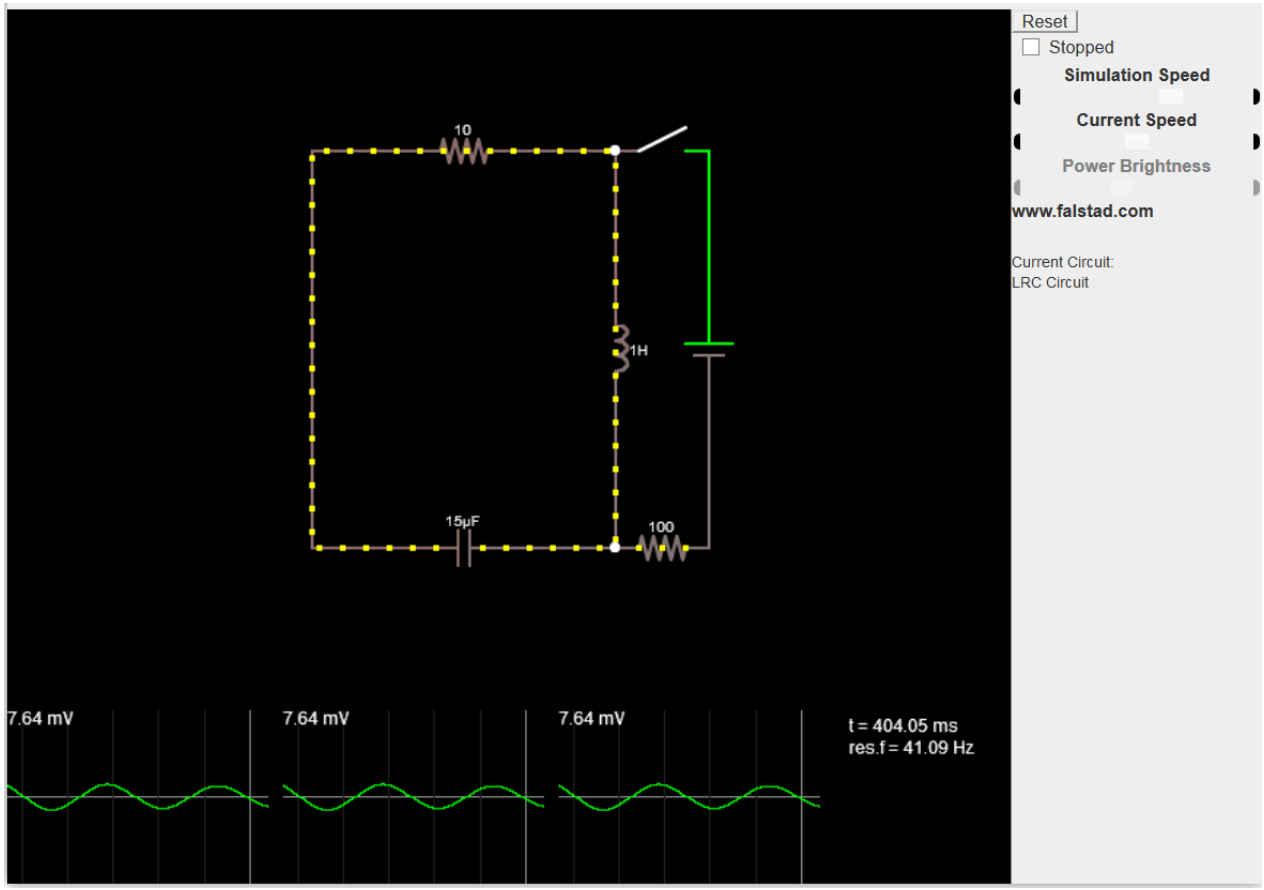


Paul Falstad

Minneapolis, MN

Beyond JSmol: SwingJS

circuit



Paul Falstad

Minneapolis, MN

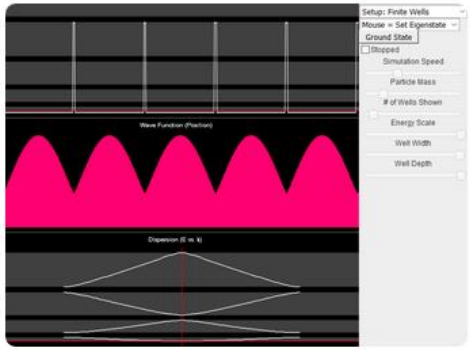
Demo Falstad Circuit

https://chemapps.stolaf.edu/swingjs/phet/site/swingjs/examples/applets/_Circuit_.html

Beyond JSmol: SwingJS

Physics - Solid State

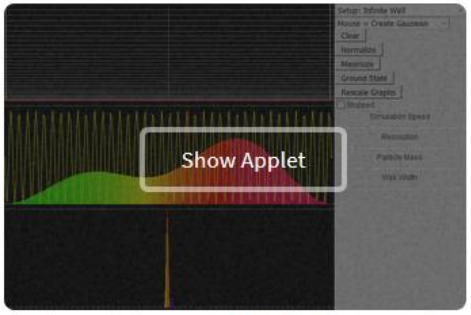
1-D Quantum Crystal



Periodic potentials in one dimension

Physics - Quantum

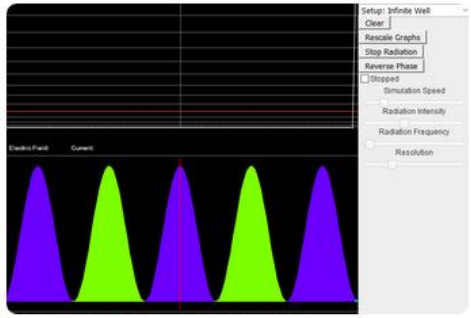
1-D Quantum States



Single-particle quantum mechanics states in one dimension

Physics - Quantum

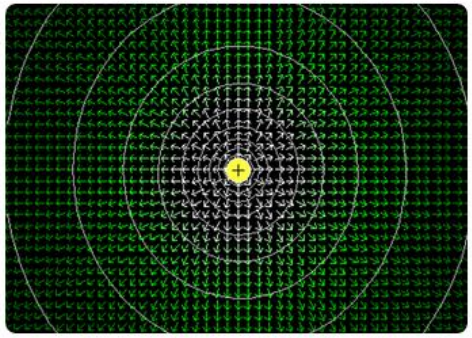
1-D Quantum Transitions



Radiative transitions (absorption and stimulated emission) in one dimension

Physics - Electromagnetics

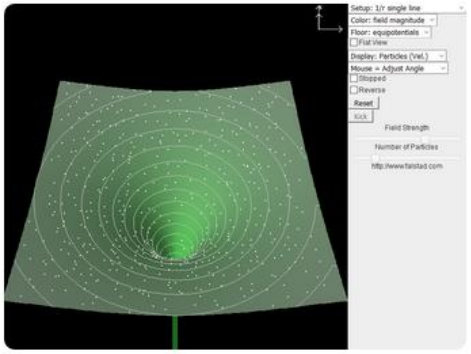
2-D Electrostatics



Demonstrates static electric fields and steady-state current

Mathematics

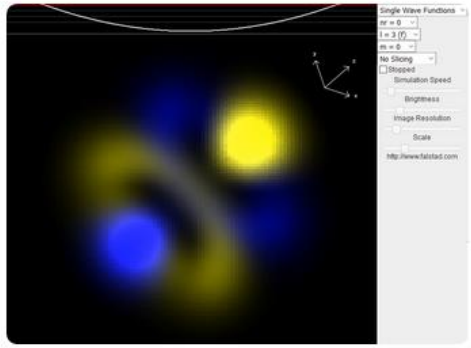
2-D Vector Fields



Demonstrates various properties of vector fields, including divergence and curl, etc.

Physics

3-D Quantum Harmonic Oscillator

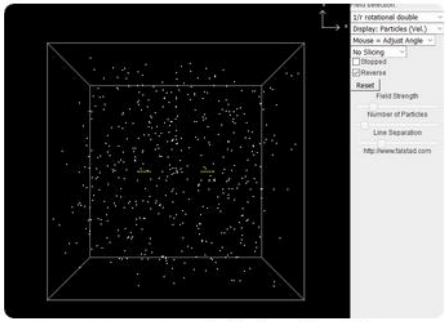


Harmonic oscillator in three dimensions

Beyond JSmol: SwingJS

Mathematics

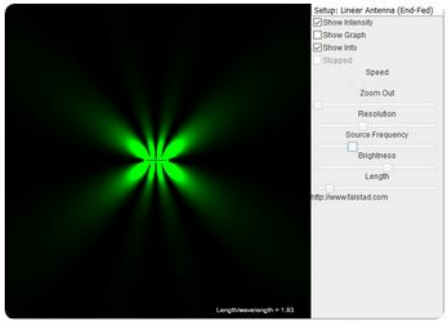
3-D Vector Fields



Demonstrates vector fields in 3 dimensions. Includes the Lorenz Attractor and Rossler Attractor

Physics - Electronics

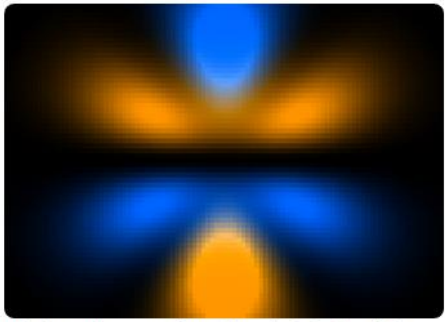
Antenna



Generates antenna radiation patterns

Physics - Atomic

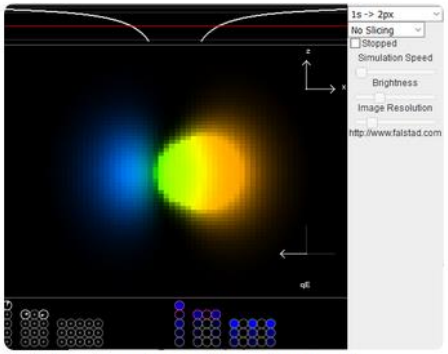
AtomViewer



Displays the wave functions (orbitals) of the hydrogen atom in 3-D

Physics - Atomic

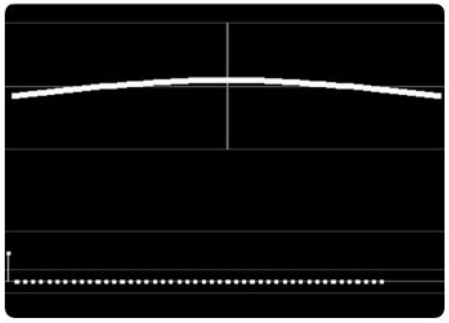
Atomic Dipole Transitions



Radiative transitions (absorption and stimulated emission) in atoms

Physics - Waves

BarWaves



A simulation that demonstrates standing flexural waves in a bar

Mathematics

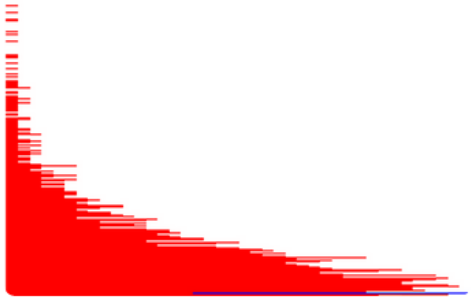
Boids

Illustrates a flocking algorithm

Beyond JSmol: SwingJS

Chemistry

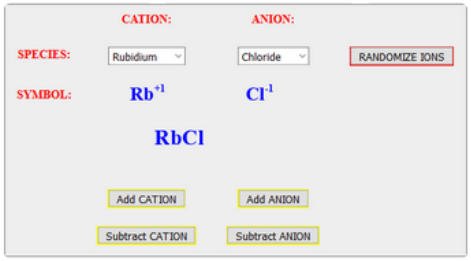
Boltzmann



A simulation of the Boltzmann distribution.

Chemistry

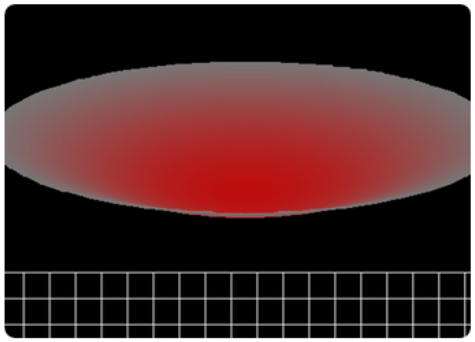
Chemical Charge



Combine charges to create a proper chemical formula

Physics - Mechanics

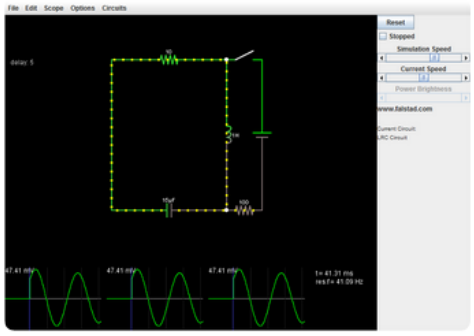
CircOsc



A simulation of waves in a circular membrane, showing its various vibrational modes.

Physics - Electronics

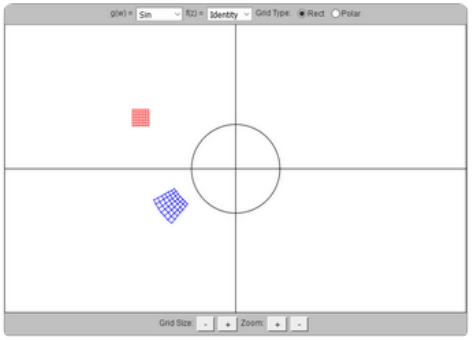
Circuit



An electronic circuit simulator. When the

Mathematics

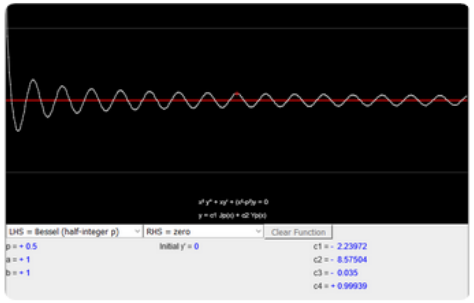
ComplexViewer



A viewer of mappings in the complex plane.

Mathematics

DiffEq

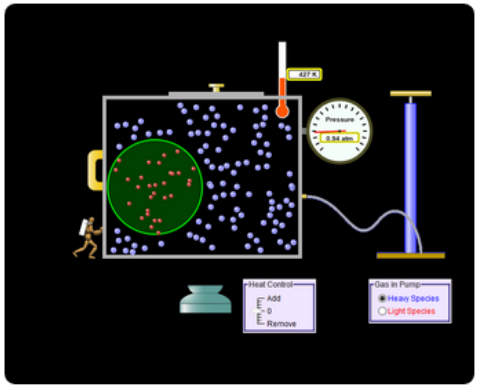


Visual differential equation solver.

Beyond JSmol: SwingJS

Chemistry - Ideal Gases

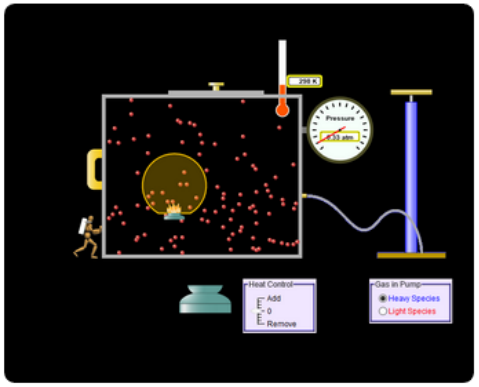
PhET Helium Balloon



Interactive ideal gas simulation involving a helium-filled balloon

Chemistry - Ideal Gases

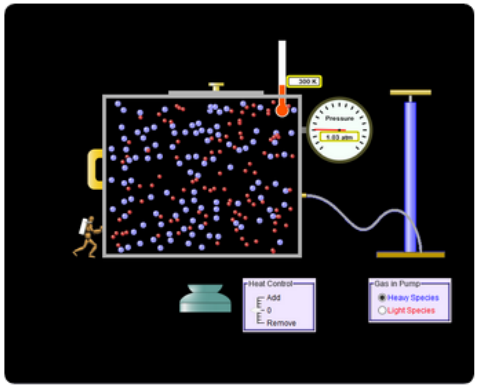
PhET Hot Air Balloon



Interactive ideal gas simulation involving a hot air balloon

Chemistry - Ideal Gases

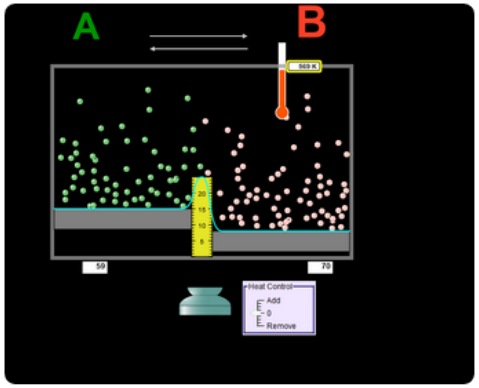
PhET Ideal Gas Properties



Ideal Gas Simulation

Chemistry - Reactions

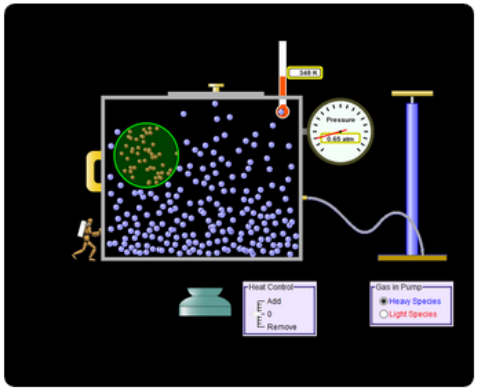
PhET Reversible Reactions



Interactive simulation of a reversible reaction

Chemistry - Ideal Gases

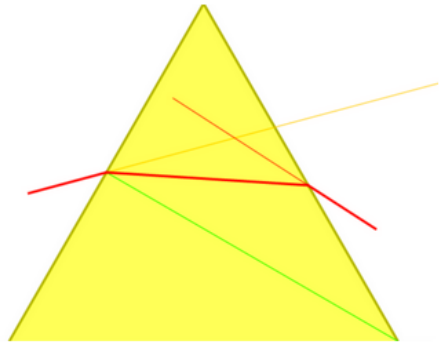
PhET Rigid Sphere



Interactive ideal gas simulation involving a

Physics - Optics

Prism

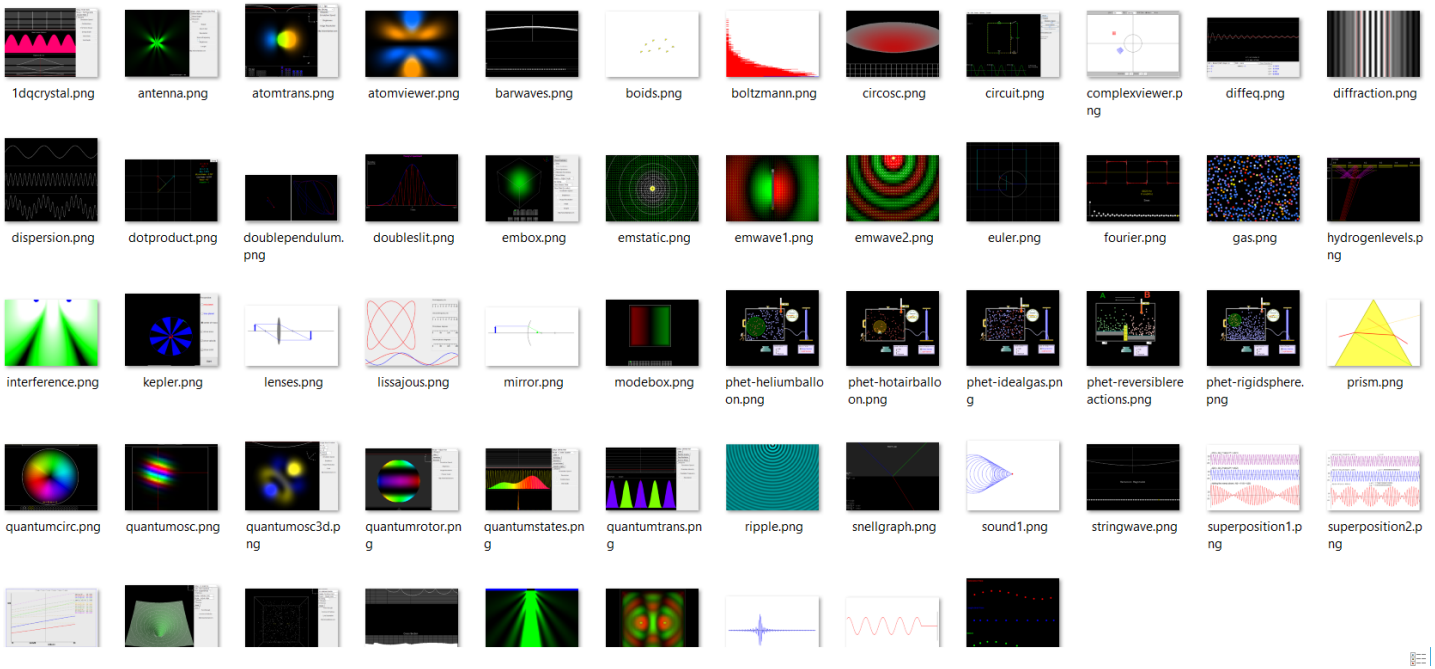


Illustrates the refraction of light by a prism

Beyond JSmol: SwingJS

Summer, 2016

– generated more than 50 applets



– discovered numerous transpiler and run-time issues

Further Generalization

Summer, 2017

Andrew Lee

Nikesh Yadav

Tahir Ahsan

Further Generalization

Zhou Renjian's first-generation transpiler was error-prone and still experimental, requiring many manually-generated work-arounds, primarily due to:

- minimal Java class implementation
- inaccurate class loading
- lack of numerical typing in JavaScript

  byte, short, int, long, float, double
- no array typing

  String[] int[] float[][] …
- no method signature overloading

  read(int) read(int, int) read(double) …

Further Generalization

enter… Udo Borkowski

independent consultant
contributor to java2script
diplom in computer science – U. of Bonn
special interest in compiler construction

“Bob, it’s all about method binding. That has to be done by the transpiler, not at run time. I’m certain it can be done.”

Further Generalization

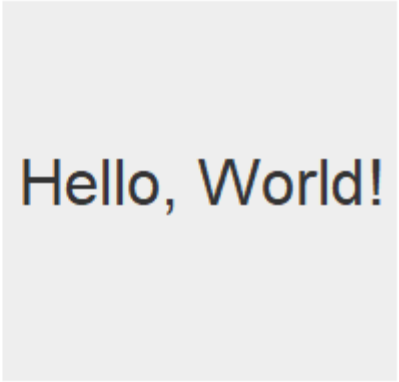
summer of 2017 into spring of 2017

- Completely rewritten transpiler now *100% consistent with Java class loading*
- Full implementation of the Java event queue
- Full numerical typing implemented for *char, byte, short, integer*, and (to the extent possible) *long*
- All method overloading issues resolved
- JavaScript single-thread issue solved

Beyond JSmol: SwingJS

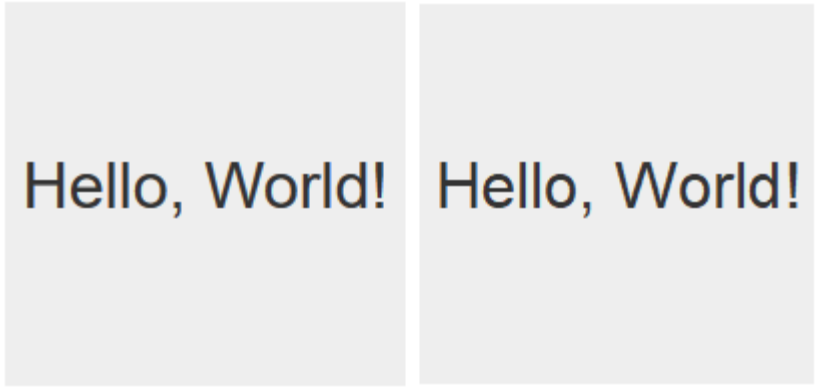
Java:

```
package test;

import java.awt.Font;
import java.awt.Label;

import javax.swing.JApplet;

public class HelloWorld extends JApplet {

    @Override
    public void init() {

        Label label = new Label("Hello, World!");
        label.setFont(new Font(Font.SANS_SERIF, Font.PLAIN, 32));
        label.setAlignment(Label.CENTER);
        add(label);

    }

}
```



Beyond JSmol: SwingJS

JavaScript:




```
var P$=Clazz.newPackage("test"),I$=[[0,'java.awt.Label','java.awt.Font']];
var C$=Clazz.newClass(P$, "HelloWorld", null, 'javax.swing.JApplet');

Clazz.newMeth(C$, ['init'], function () {
  var label=Clazz.new_($I$(1).c$$S,["Hello, World!"]);
  label.setFont$java_awt_Font(Clazz.new_($I$(2).c$$S$I$I,["SansSerif", 0, 32]));
  label.setAlignment$I(1);
  this.add$java_awt_Component(label);
});
```

Demo HelloWorld and Eclipse

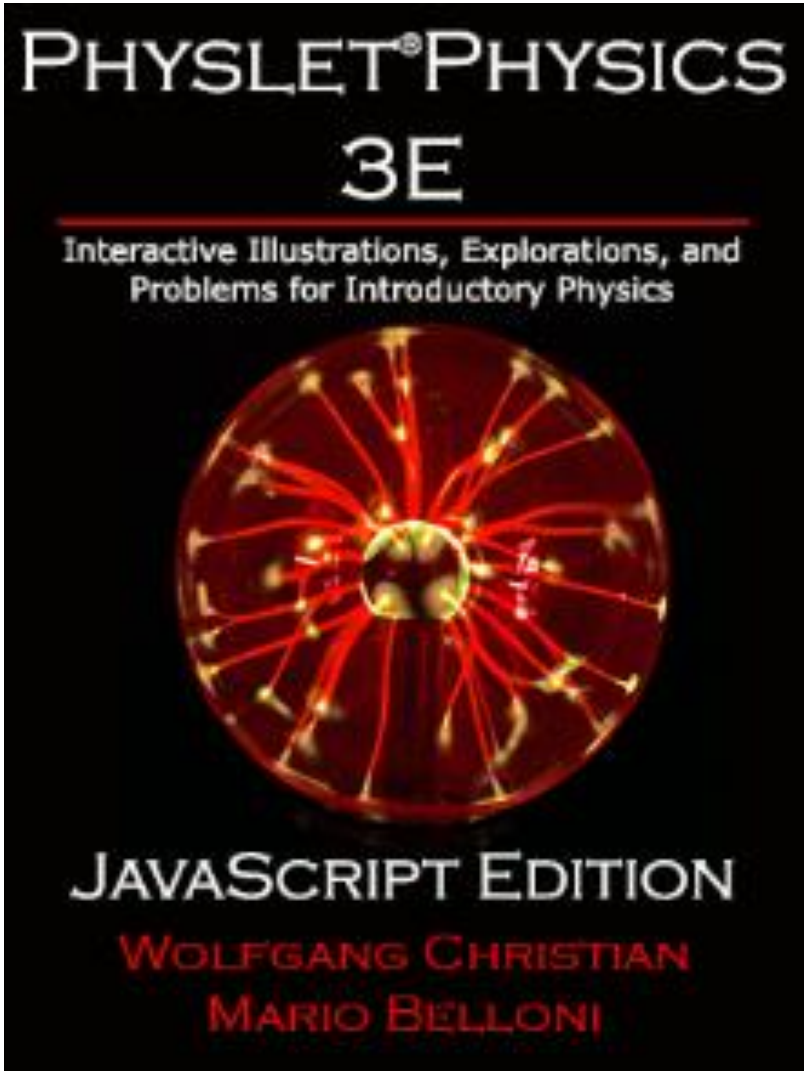
Current Collaborations

spring/summer of 2018
- present

Physlet Physics
Wolfgang Christian
Davidson College

39 chapters of interactive on-line introductory physics

30 applets; 800+ simulations
1500 Java classes



Current Collaborations

summer of 2018 – present

Jalview

Geoff Barton

University of Dundee

desktop application

200,000 lines of code

3000 Java classes

Current Collaborations

fall of 2018 - present

Mathe (Prism)a

Mathe-Prisma

Karsten Blankenagel

Wuppertal University

53 modules

500+ applets

1000+ web pages

4400 Java classes

Algebra
Arithmetik
Analysis
Geometrie
Graphentheorie
Stochastik
Informatik

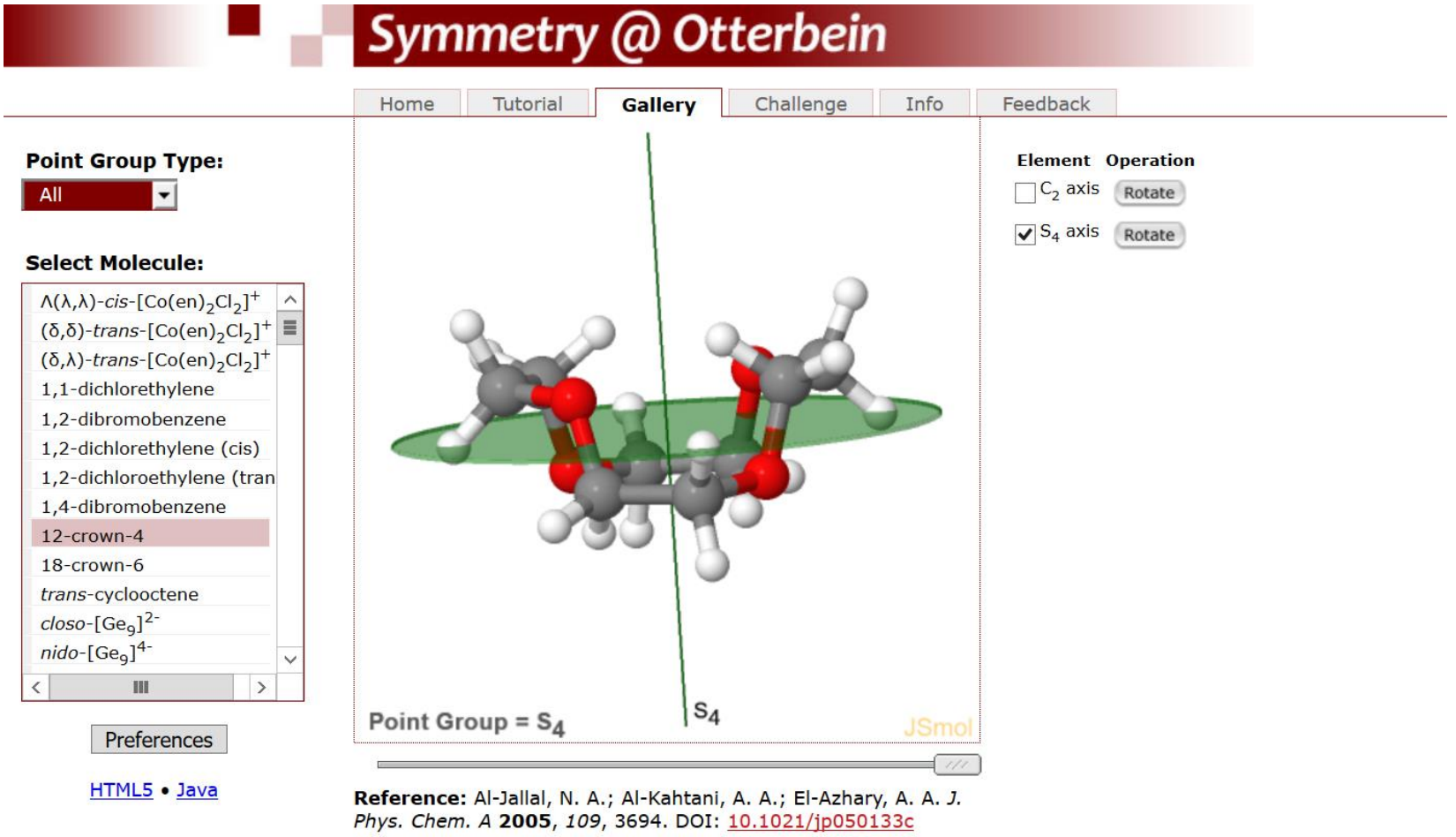
Historical Context

The Problem and its Solution

Where we are now

Where we are headed

The Cost of Progress



Dean Johnston http://symmetry.otterbein.edu/gallery/

The Cost of Progress

Awards

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About Awards

How to Manage Your Award

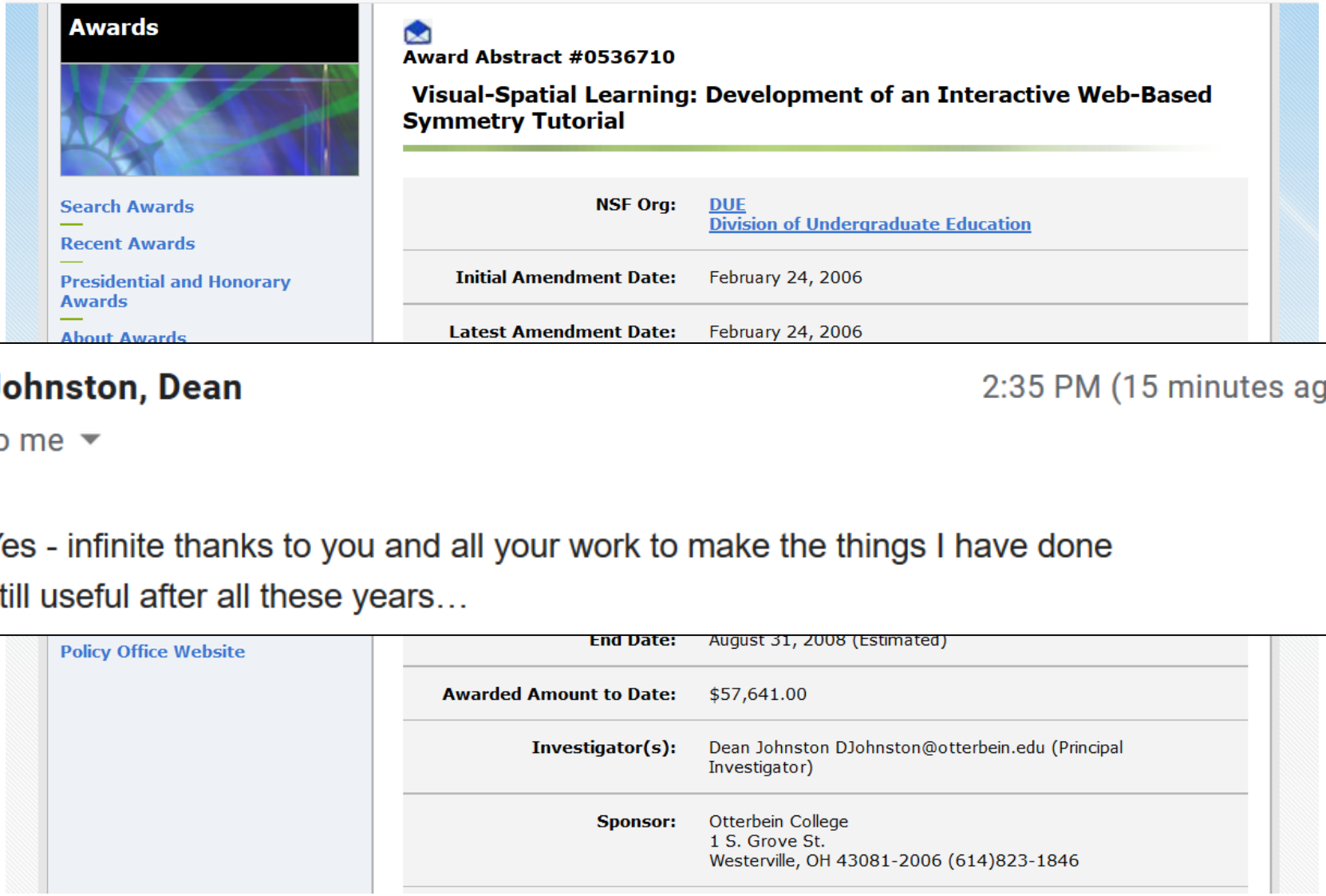
Grant Policy Manual
Grant General Conditions
Cooperative Agreement Conditions
Special Conditions
Federal Demonstration Partnership
Policy Office Website

Award Abstract #0536710

Visual-Spatial Learning: Development of an Interactive Web-Based Symmetry Tutorial

NSF Org:	DUE Division of Undergraduate Education
Initial Amendment Date:	February 24, 2006
Latest Amendment Date:	February 24, 2006
Award Number:	0536710
Award Instrument:	Standard Grant
Program Manager:	Eileen L. Lewis DUE Division of Undergraduate Education EHR Directorate for Education & Human Resources
Start Date:	April 1, 2006
End Date:	August 31, 2008 (Estimated)
Awarded Amount to Date:	$57,641.00
Investigator(s):	Dean Johnston DJohnston@otterbein.edu (Principal Investigator)
Sponsor:	Otterbein College 1 S. Grove St. Westerville, OH 43081-2006 (614)823-1846

…and the reward for success



Johnston, Dean 2:35 PM (15 minutes ago)

to me

Yes - infinite thanks to you and all your work to make the things I have done still useful after all these years…

The Cost of Progress

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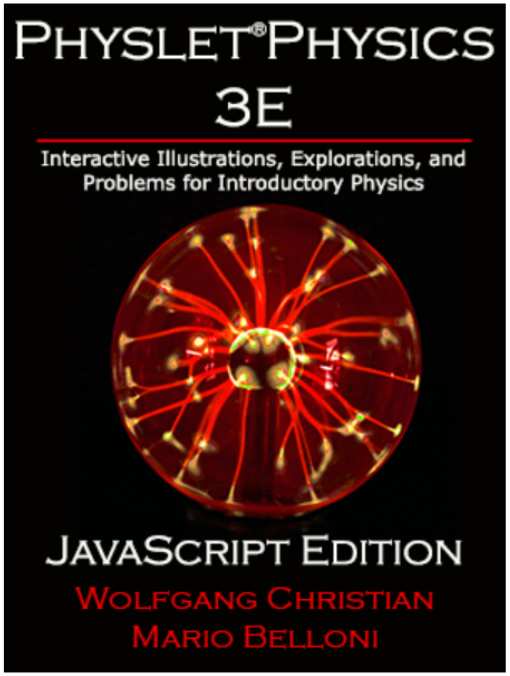
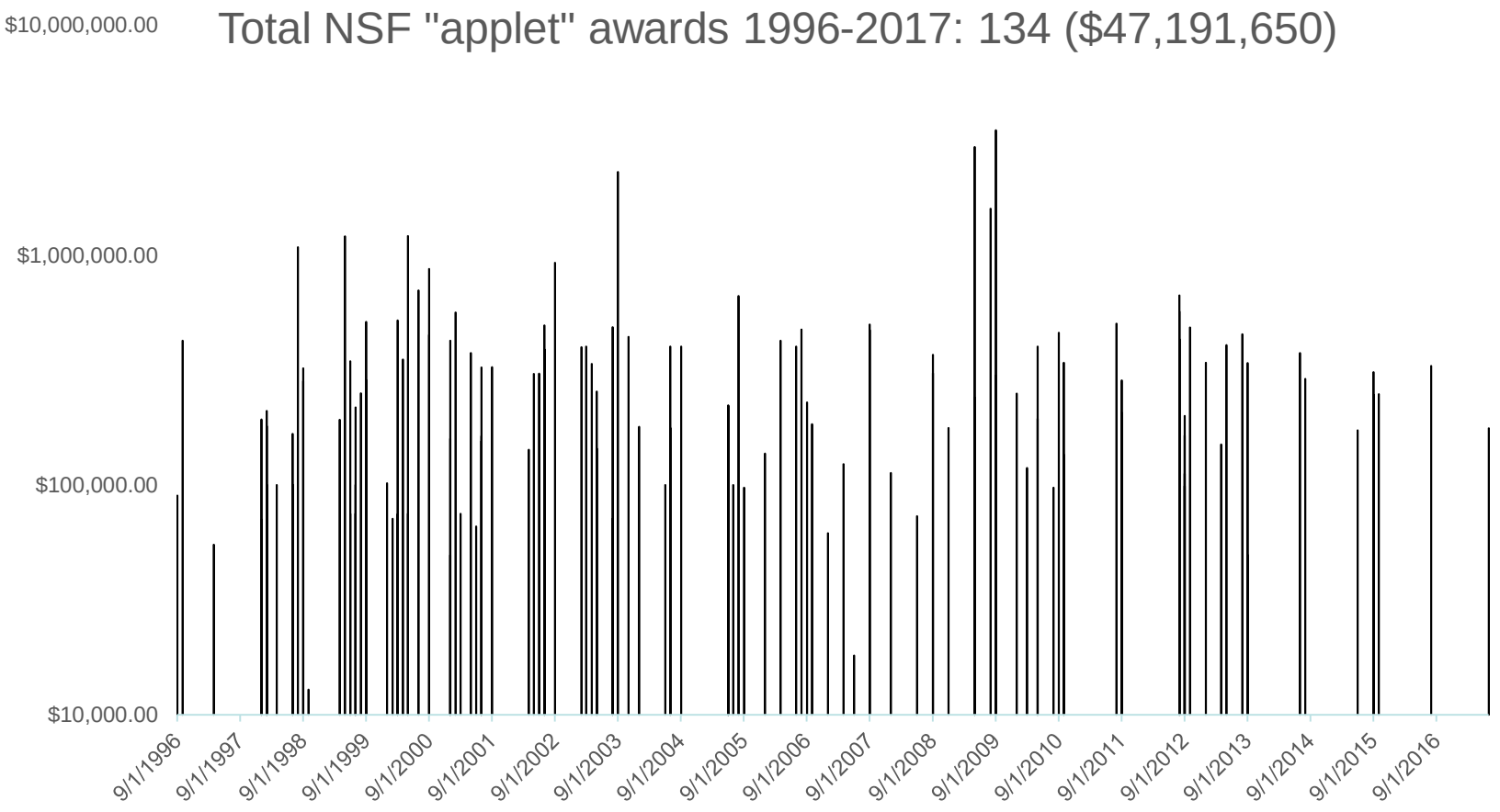


NSF Awards – “physlets” $2,272,543

Title	Award
Ubiquitous Contextual Access to STEM Educational Resources (UCASTER)	$521,702
Cross-Linked Models (XLM)	$149,977
OPTIC: Open Physics Technology for Interactive Curricula	$450,000
Revising intermediate optics for greater conceptual understanding and the development of complex problem solving skills	$60,566
Open-Source Physics EducatioN: OPEN	$494,715
Creation of a Computation and Visualization Laboratory	$53,466
Multimedia-focused Kinematics Questions: An Innovative Approach to Teaching Kinematics	$74,410
Computerizing Introductory Physics Laboratories to Improve Student Learning	$31,545
Implementing the Workshop Model and other Research-based Instructional Strategies in Physics & Mathematics Courses	$81,207
Studio Based Modern Physics	$50,205
WebPhysics	$304,750

NSF Awards – “applets” $47,191,650



NSF Awards – “applets”
$47,191,650

Summary

- SwingJS “proof of concept” is complete – around 10,000 Java classes implemented and working smoothly.
- Developer tools are now in place so that others can proceed with minimal assistance (GitHub, Eclipse).
- Still a few Java Swing classes to fully implement (e.g. JTree). Testing/debugging continues.
- Not totally automatic. A certain amount of Java redesign may be necessary, and performance optimization is critical.

Summary

- The success of Jmol/JSmol has been generalized to a wide range of Java applets and applications across the fields of mathematics, physics, chemistry, and biology.

- Java may be gone from the web, but, oddly enough, that is not the case for *Java applets! They can live on as JavaScript.*

- java2script/SwingJS allows for re-enabling $Ms of superb resources that have been lost in the past few years.

- Our technology allows for a novel “Java+JavaScript” option for web app and stand-along application developers.

Thanks!

St. Olaf Students

Nadia El Mouldi
Andreas Raduege

Andrew Lee
Tahir Ahsan
Nikesh Yadav

Thanks!

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Thanks!

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Friends at St. Olaf

Matt Richey
Dick Brown
Olaf Hall-Holt

MSCS for use of anansi server (https://chemapps.stolaf.edu)

Thanks!

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and you, for your attention