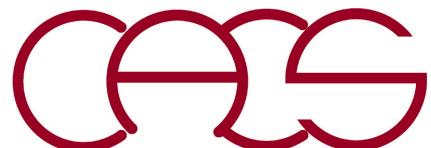


Virtual Reality Application

Aiichiro Nakano

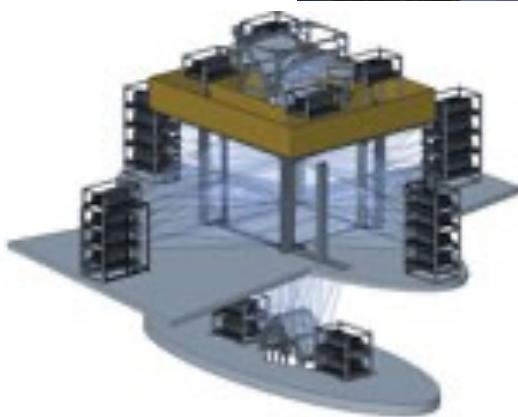
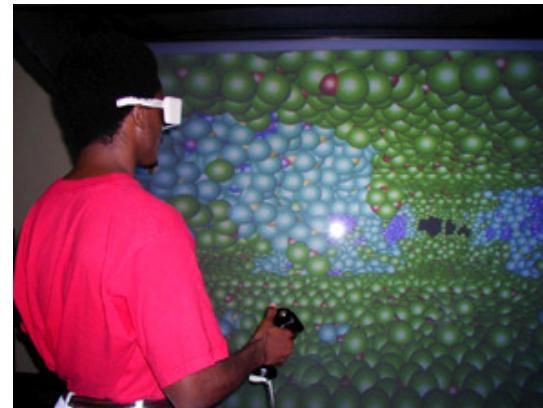
*Collaboratory for Advanced Computing & Simulations
Department of Computer Science
Department of Physics & Astronomy
Department of Quantitative & Computational Biology
University of Southern California*

Email: anakano@usc.edu



CAVE Visualization System

- CAVE (CAVE Automatic Virtual Environment): A fully immersive & interactive 10^3 virtual environment (VE)
- ImmersaDesk: A semi-immersive with a $4' \times 5'$ display



CAVE



C6 at Iowa-State VRAC

<https://www.vrac.iastate.edu>

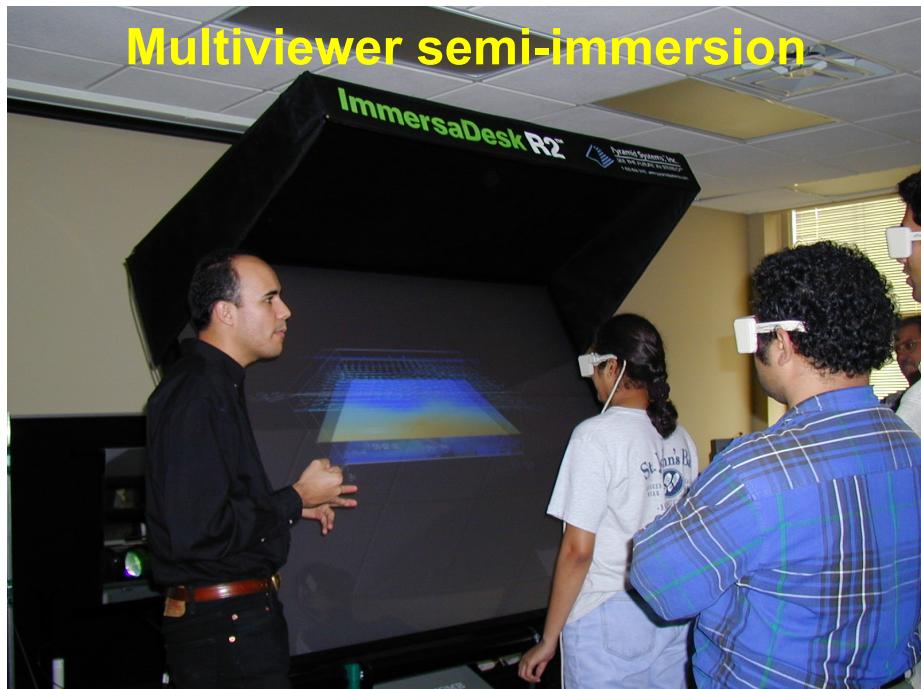
<https://www.mechdyne.com>



ImmersaDesk

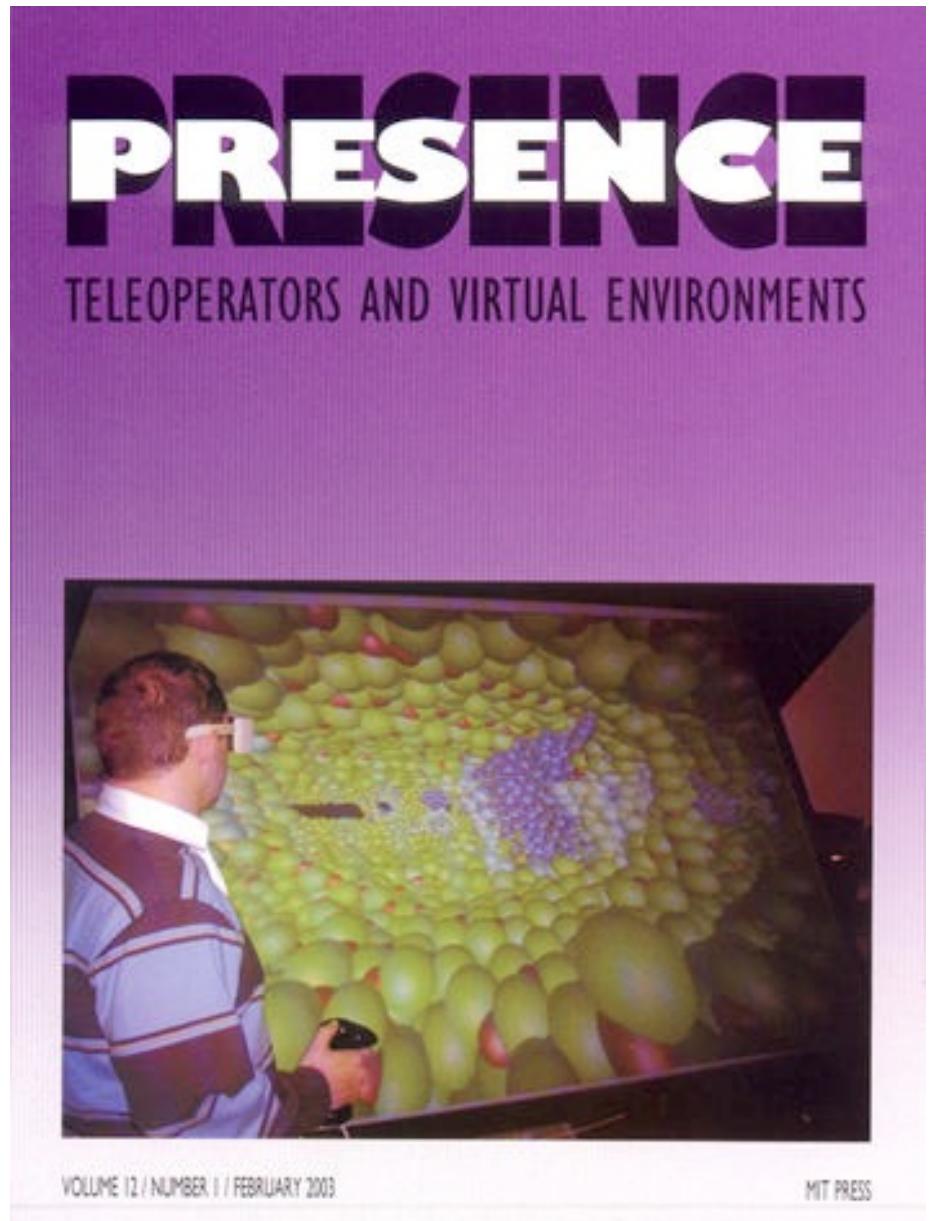
Billion-Atom Walkthrough

- Achieved real-time walkthrough for a billion atoms in ImmersaDesk



IEEE Virtual Reality Best Paper

<https://aiichironakano.github.io/cs596/Sharma-Viz-Presence03.pdf>

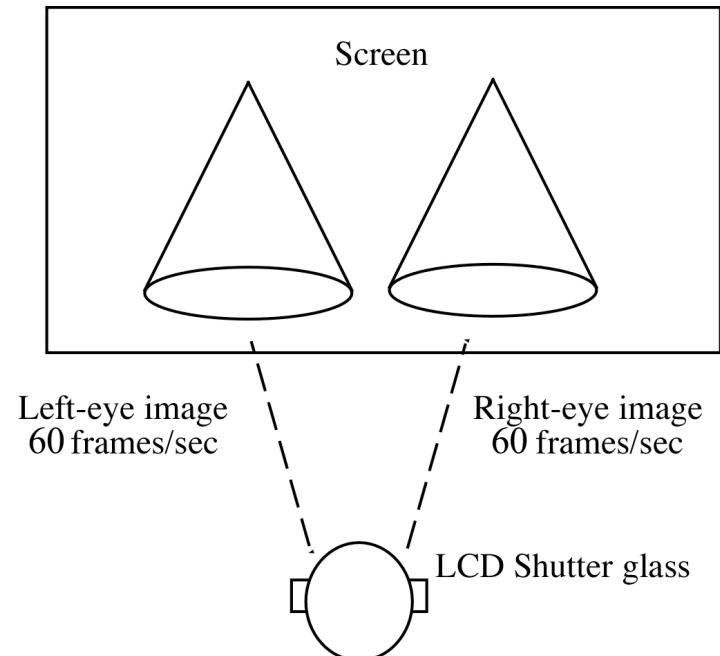
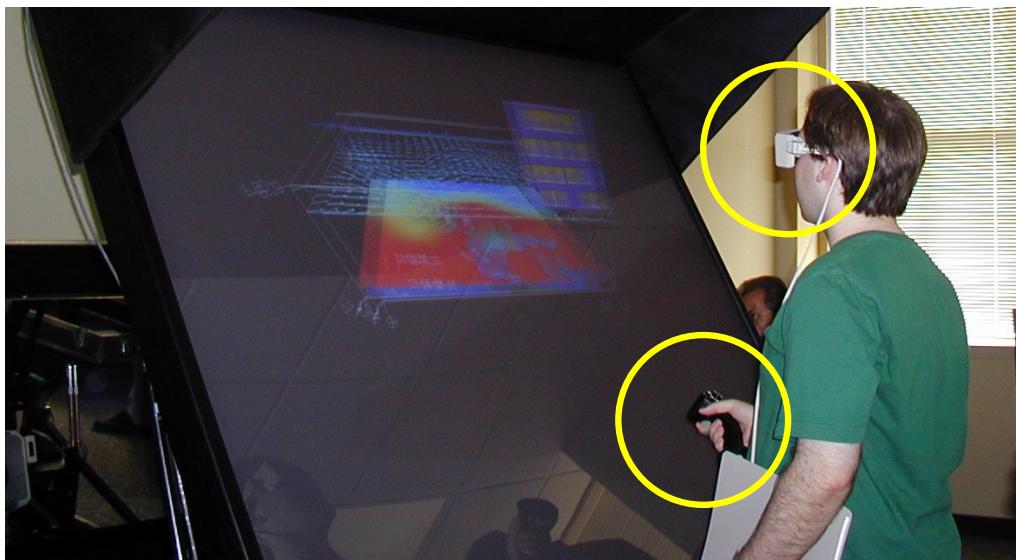


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MIT PRESS

CAVE Components

- **Stereographics:** The projector interleaves images for left & right eyes at a rate of 120 frame/s synchronized with an LCD shutter glass *via* an infrared emitter; 3D perception is created by showing the two eyes slightly rotated objects
- **Wand:** A 3D mouse with buttons; the position & angle of the wand as well as button press are user inputs (*cf.* Wii)
- **Magnetic tracking system:** A sensor is attached to a user's head so that the scene can be changed according to the user's position (*cf.* gluLookat())

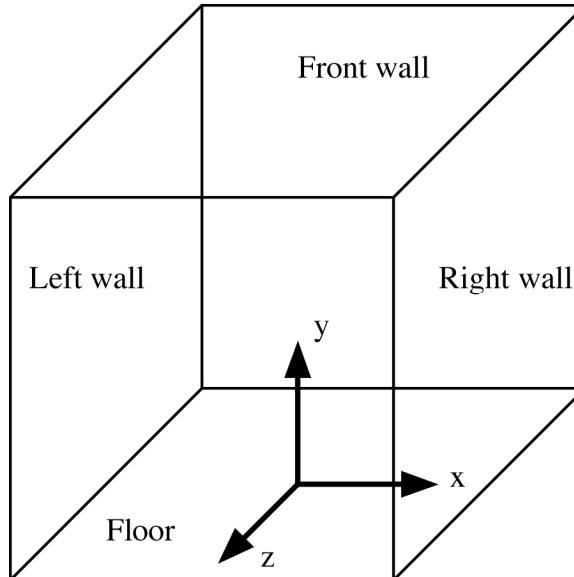


CAVE Programming

- **CAVE library:** A library of C functions & macros to control the operation of the CAVE: keep all the devices synchronized; produce the correct perspective for each wall; & provide the applications with the current state of all the CAVE elements
- **Compiling a CAVE application:**

```
LIBS = -L/usr/local/CAVE/lib32 -lcave_ogl -lGLU -lGL -lXi -lX11 -lm  
cc -O -o ball ball.o $(LIBS)
```

- **CAVE coordinate system: 10^3 with the origin at the central floor**



<https://www.evl.uic.edu/pape/CAVE/prog>

Example: ball.c

```
#include <cave_ogl.h>
#include <GL/glu.h>

void main(int argc,char **argv) {
    CAVEConfigure(&argc,argv,NULL); CAVEInit(); // Initialize the CAVE
    CAVEInitApplication(init_gl,0); // Pointer to GL initialization function
    CAVEDisplay(draw_ball,0); // Pointer to drawing function
    while (!CAVEgetbutton(CAVE_ESCKEY)) sginap(10); // Continue until ESC hit
    CAVEExit();}
}

void init_gl(void) {
    float redMaterial[] = { 1, 0, 0, 1 };
    glEnable(GL_LIGHT0);
    glMaterialfv(GL_FRONT_AND_BACK, GL_AMBIENT_AND_DIFFUSE, redMaterial);
    sphereObj = gluNewQuadric();}

void draw_ball(void) {
    glClearColor(0., 0., 0., 0.);
    glClear(GL_DEPTH_BUFFER_BIT|GL_COLOR_BUFFER_BIT);
    glEnable(GL_LIGHTING);
    glPushMatrix();
    glTranslatef(0.0, 4.0, -4.0);
    gluSphere(sphereObj, 1.0, 8, 8);
    glPopMatrix();
    glDisable(GL_LIGHTING);}
```

VR on Web: X3D

- **X3D is an open standards XML (extensible markup language)-enabled 3D file format for real-time communication of 3D data across applications over network**
- **With X3D browsers and plug-ins, X3D becomes immersive allowing a user to walk through the 3D scene**
- **An X3D file is publishable directly on the World Wide Web; an X3D browser acts as a helper application at the client side**
- **X3D homepage**
<https://www.web3d.org>
- **X3D plug-ins for Windows, Macintosh, and Linux**
<https://www.web3d.org/x3d/content/examples/X3dResources.html>

See also Quicktime VR: https://en.wikipedia.org/wiki/QuickTime_VR

Tsunami on Web

Patrick Lynett, Zili Zou *et al.*, [Nature 609, 728 \('22\)](https://doi.org/10.1038/nature22077)

Metaverse Is Coming?

The New York Times

October 28, 2021

Facebook Renames Itself Meta

The social network, under fire for spreading misinformation and other issues, said the change was part of its bet on a next digital frontier called the metaverse.



Metaverse is a speculative future iteration of the Internet, made up of persistent, shared, 3D virtual spaces linked into a perceived virtual universe.



Four choreographers team up with leading scientists to create cutting-edge, AI and metaverse-inspired performances.

<https://en.wikipedia.org/wiki/Metaverse>

3D in Hollywood

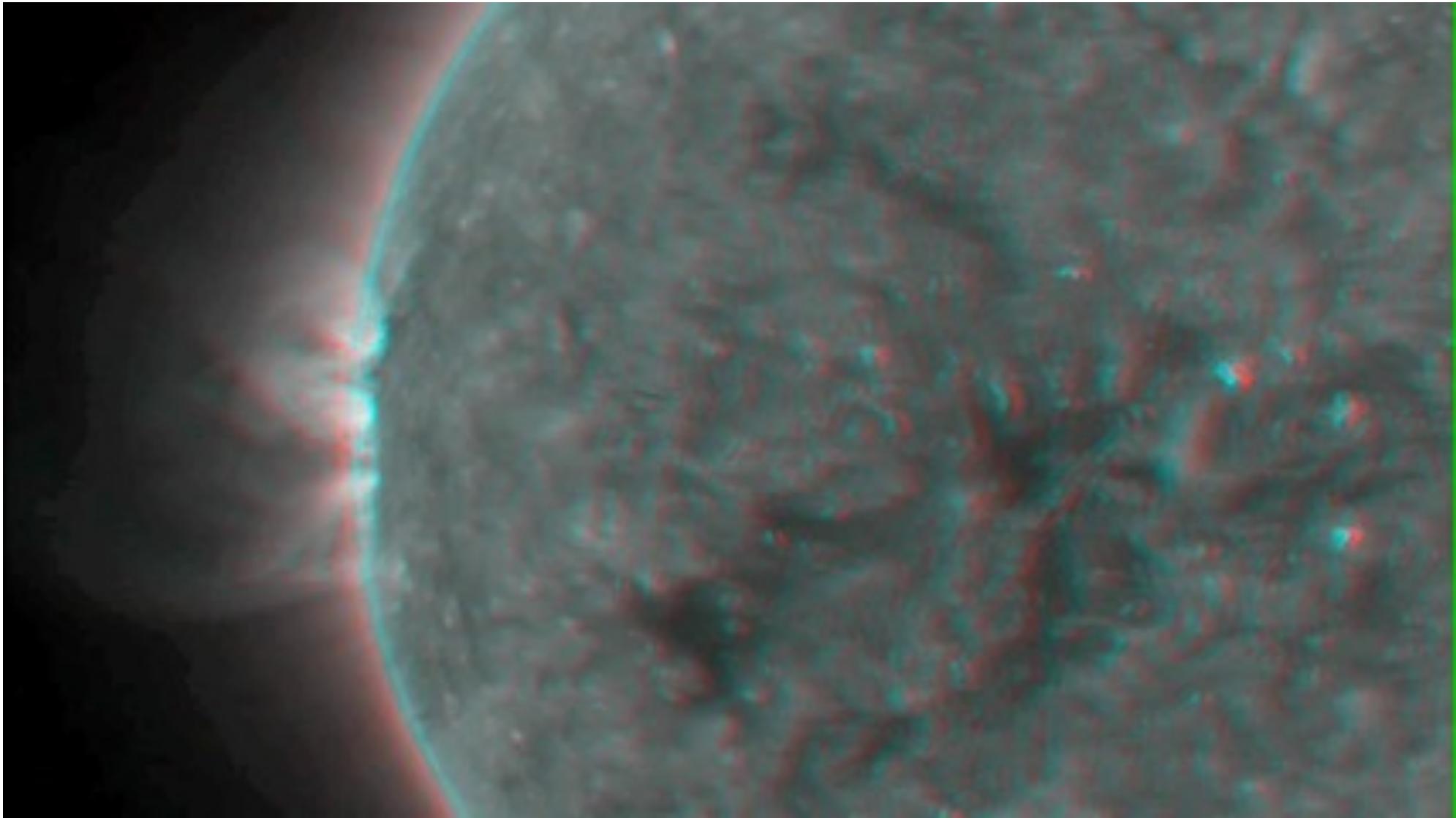


© 3D Wallace '10

<https://www.youtube.com/watch?v=avecKPWqYqM>

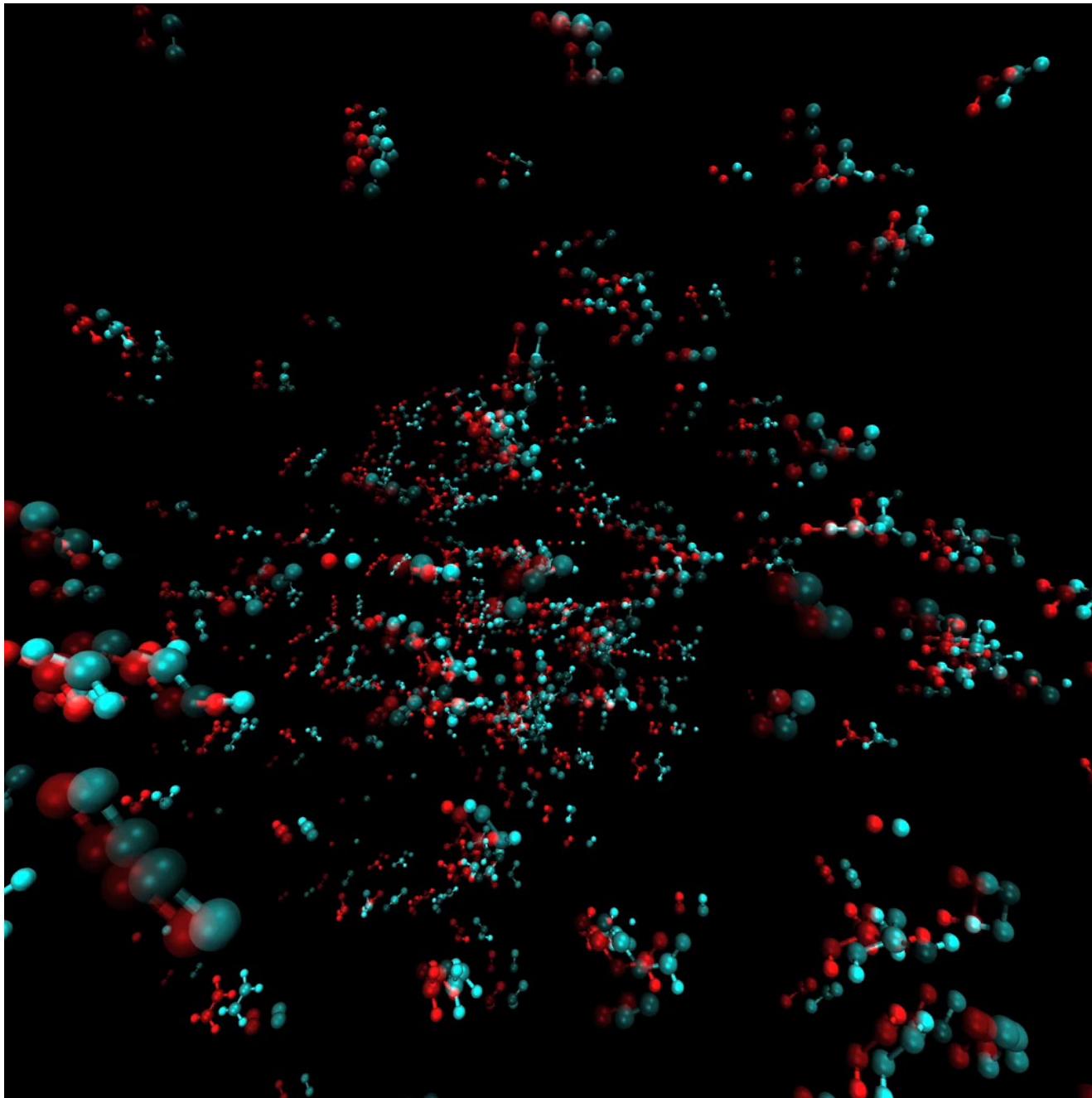
3D in Science

- **Anaglyph:** Stereoscopic 3D effect by means of encoding each eye's image using filters of different colors (typically red & cyan).



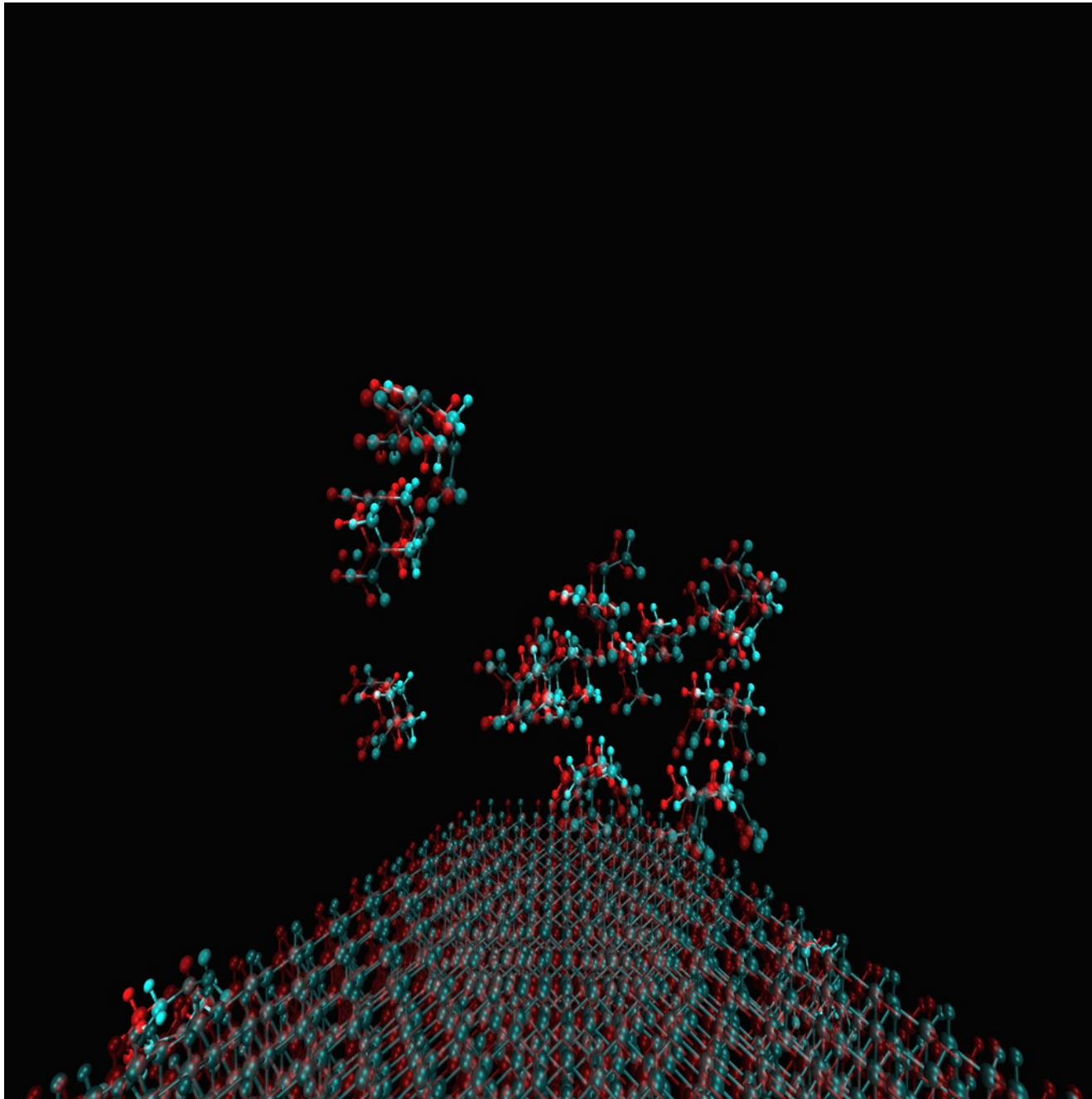
http://www.nasa.gov/mission_pages/stereo/news/stereo3D_press.html

3D in Molecular Dynamics (1)



K. Nomura et al.,
Phys. Rev. Lett.
99, 148303 ('07)

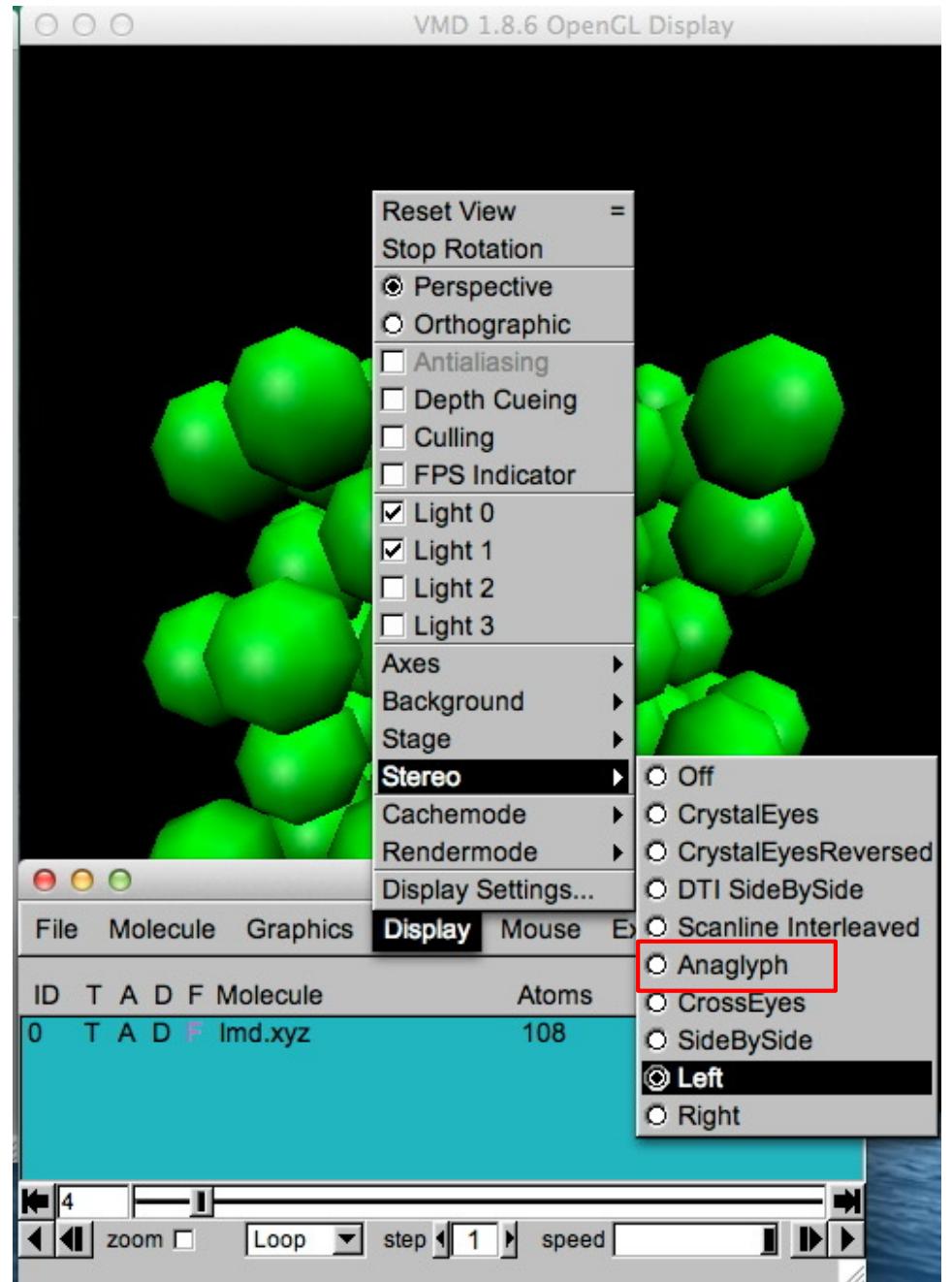
3D in Molecular Dynamics (2)



Y. Chen *et al.*,
Appl. Phys. Lett.
93, 171908 ('08)

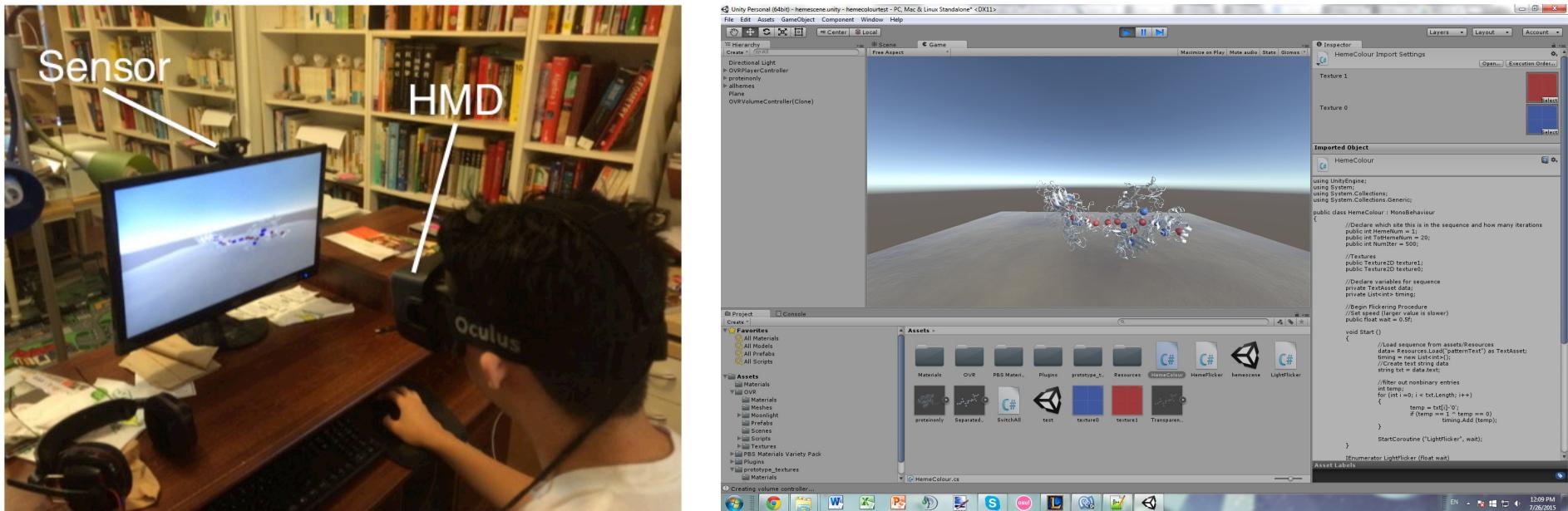
How to Make Anaglyph Stereo

- In the main window of the VMD software, go to the **Display** menu, then the **Stereo** submenu
- Select the **Left** view & save the image as an image file
- Next select the **Right** view & save the image as another image file
- Use software such as Photoshop to make an anaglyph by image processing
- Or, simply select **Anaglyph** option



Commodity Virtual Reality

- Immersive visualization to every scientist's desktop:
Exported VMD animation to a VR platform — Oculus Rift head mounted display (HMD) — using Unity game engine to increase the perceptive depth



- In VMD, File → Render as waveform object & material (texture) files; then, use Blender (3D editor software, <https://www.blender.org>) to make it compatible with Unity

https://en.wikipedia.org/wiki/Alex_McDowell

C. M. Nakano, E. Moen, H. Byun, H. Ma, B. Newman, A. McDowell, T. Wei, & M. Y. El-Naggar,
iBET: Immersive visualization of biological electron-transfer dynamics,
Journal of Molecular Graphics & Modelling 65, 94 ('16)

GEARS: VR to Every Scientist's Desktop

GEARS (Game-engine-assisted research platform for scientific computing) allows scientists to develop & perform immersive & interactive simulations within commodity virtual reality (VR) platforms



Oculus Rift + Leap Motion

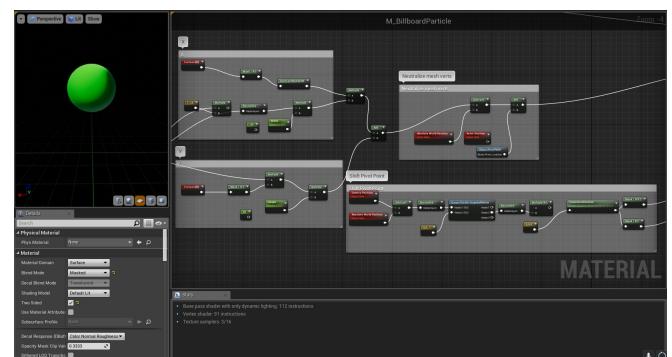


HTC Vive



Exfoliation of MoS₂

- Implemented simulation workflows in VR-capable Unity & Unreal game engines
- Enhanced interaction utilities, e.g., virtual confocal microscopy
- Developed an interface with community MD software, LAMMPS, & demonstrated immersive & interactive 250K-atom simulations on desktop



LammpsVR editor



<https://github.com/USCCACS/GEARS>

B. Horton, E. Moen, K. Nomura *et al.*, [SoftwareX 9, 112 \('19\)](#)

New Models



Meta Quest 3S Headset

Batman

\$299.99

Meta & more

Free delivery

4.7 (7.3K)

Apple Vision Pro

\$3,499.00

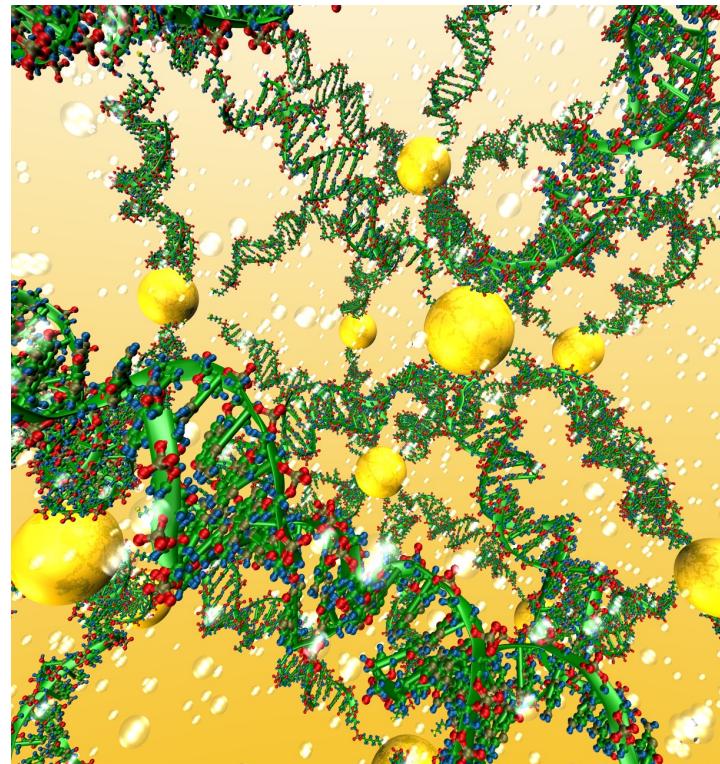
Apple & more

⌚ 2.2 mi · In stock

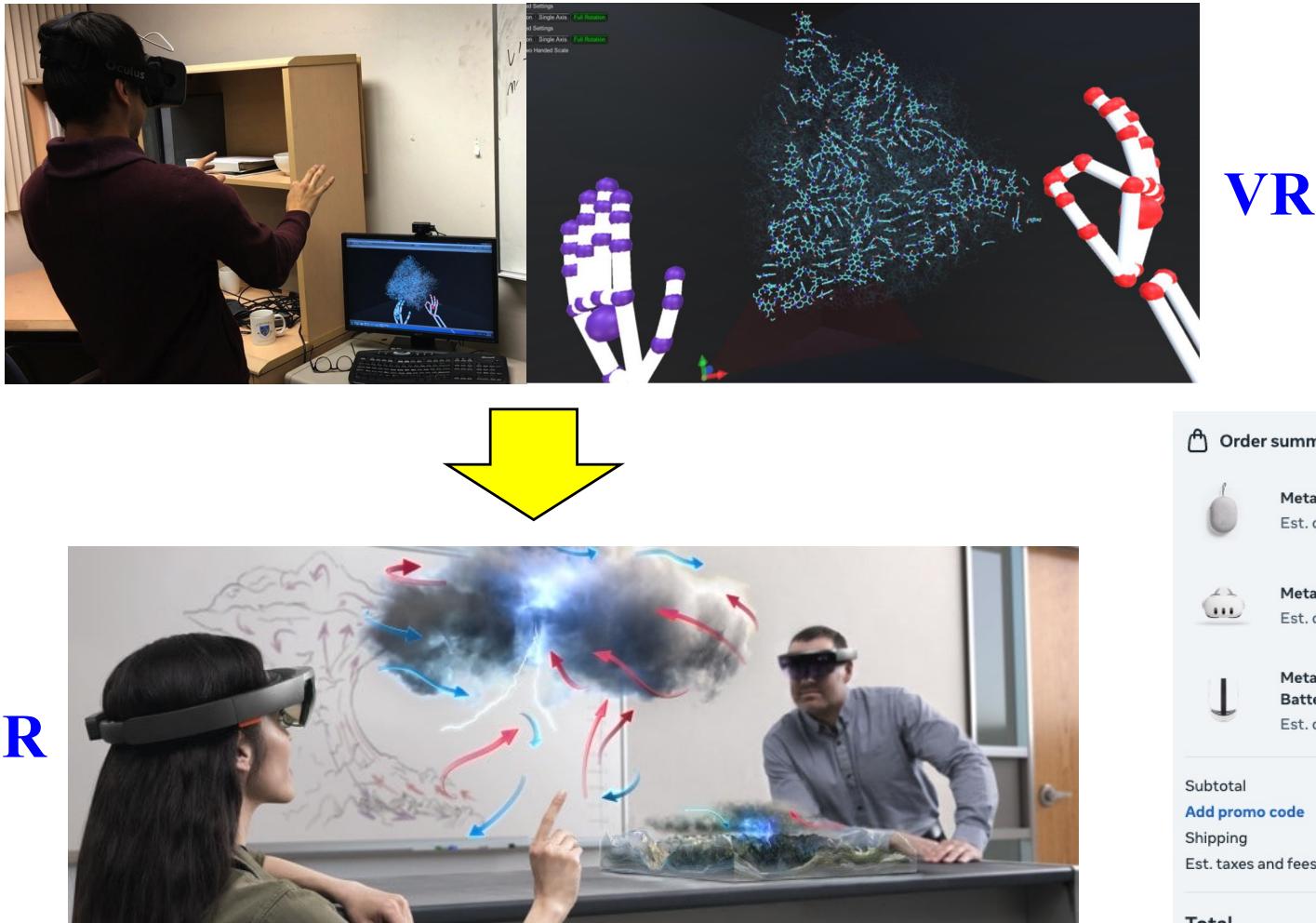
4.1 (298)

JPCC 116, 19579 ('12)

Render a Christmas gift?



Scientific Augmented Reality?



Microsoft mixed reality (MR) academic seeding program at USC
“Million-atom shared immersion?”

cf. CSCI 538: Augmented, Virtual and Mixed Reality

Augmented-Reality Tsunami



Zili Zou (Patrick Lynett Lab), Ph.D. thesis, USC