

360° Videos: Immersive Views of Astrophysical Simulations

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Phantom Workshop

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Introduction

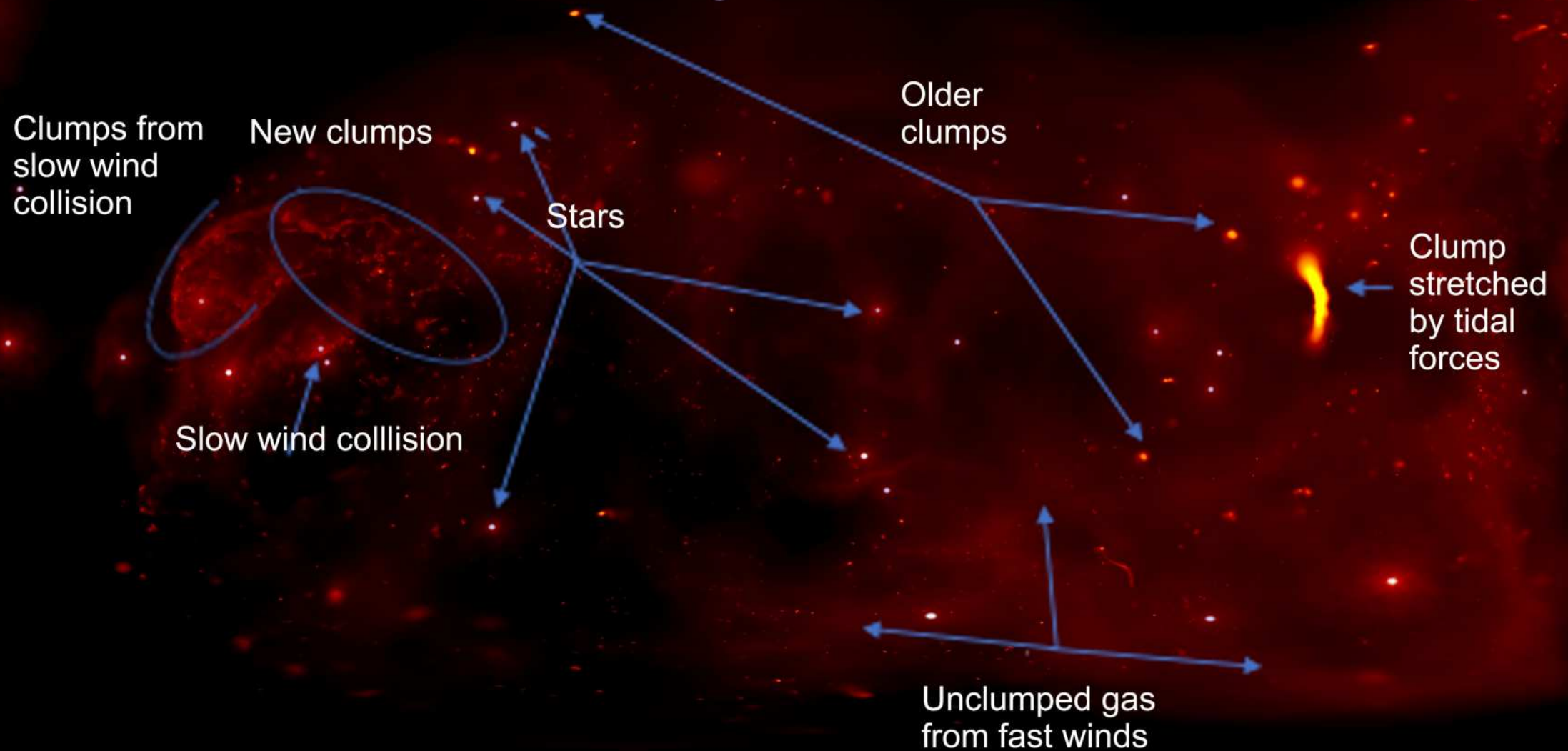
- 360° video: a movie rendered in every direction
 - Nomenclature is unfortunate: “ 4π sr” video is more accurate
- Increasingly popular form of photography/videography
 - Multiple cameras are configured to cover all 4π sr
- Folks want to share their 360°-camera movies → YouTube and Facebook developed the technology to do this
 - Good for us since we can share ours, too
- Sharing methods: Virtual Reality (VR) goggles, smartphones, computers
 - Whomever* can see a regular video can also see a 360° video

*subject to having the necessary browser or app

Distinction between VR and 360°

- Both 360° and VR allow the **viewer to look** wherever they choose
- **VR** goes one step further where the **viewer can move** as well
 - 1. Move up, down, left, right, front, back with controllers
 - 2. Walk to move left, right, front, back (sensors determine your location) and go up, down with controller
- Therefore, VR is rendered in real time (requiring high-quality gpus) where 360° videos are pre-rendered
 - Creators of 360° videos chooses the observer's location
 - Observers of VR videos chooses their own locations
- **VR is less sharable than 360° videos** since higher level of technology required

360° video of the Galactic center



360° video of the Galactic center

1. Zoom into simulation

2. 500 yr of **no-outburst** simulation

3. Rewind to show...

4. 625 yr of **outburst** simulation:
no accreting clumps

5. Zoom out of simulation

Clumps from
slow wind
collision

Clump
stretched
by tidal
forces

360° video in VR goggles

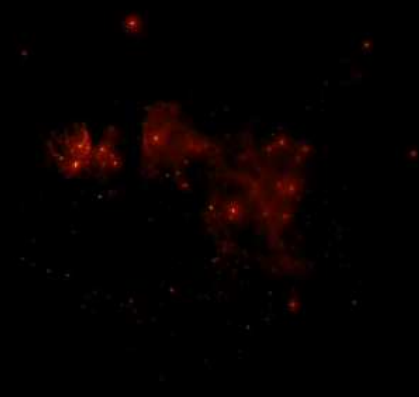
1. Zoom In

2. **No-outburst**

3. Rewind

4. **Outburst**

5. Zoom out



Hydro sims:
Cuadra+08,15

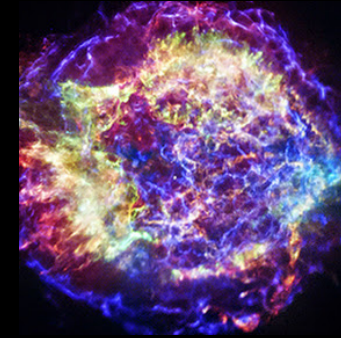
Watch the **360° video** in its native format

Android: QR code → **YouTube app**



Other smartphones: Open **YouTube App** → Search “Chandra X-ray”

channel icon:



Laptop: youtube.com/user/cxcpub

Smartphone and Laptop: Choose video
“**360-Degree Video – An Immersive Visualization of the Galactic Center**”

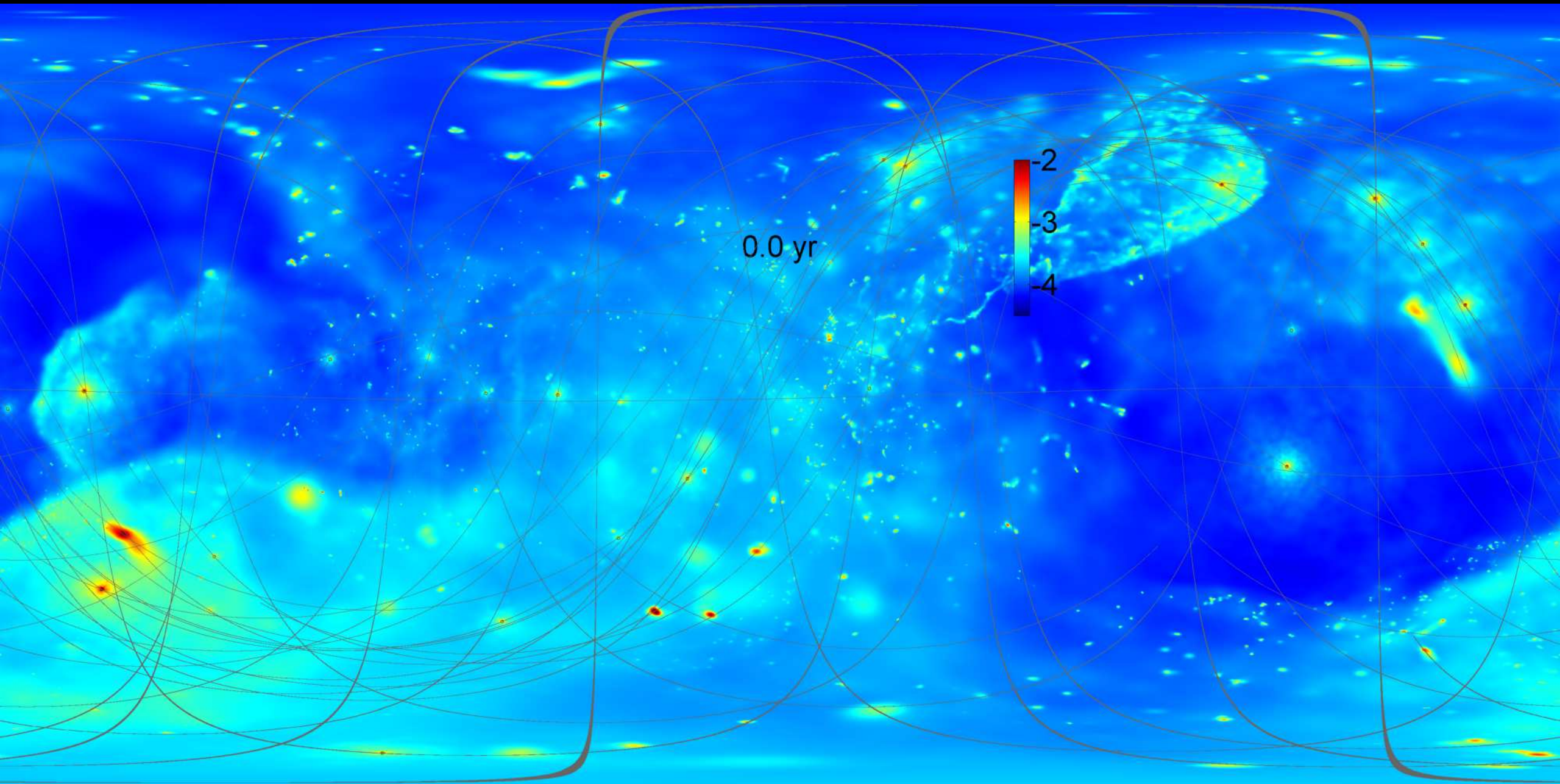
(Or find link on Twitter: @chrastropher)

Constructing 360° videos

Russell17

arXiv:1707.06954

- Make images in equirectangular projection: **polar vs azimuthal angle**



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 - Conveniently now in Splash!
- Images → Movie, e.g. using ffmpeg
 - `ffmpeg -framerate 30 -i splash_%04d.png -r 30 -c:v libx264 -crf 15 -pix_fmt yuv420p 360movie.mp4`

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 - `ffmpeg -framerate 30 -i splash_%04d.png -r 30 -c:v libx264 -crf 15 -pix_fmt yuv420p 360movie.mp4`
- YouTube: Add metadata to file to signify 360° video, then upload
 - <https://support.google.com/youtube/answer/6178631>
 - Note: don't modify the video once metadata is added (no YouTube tools)
- Facebook: check 360° option when uploading
 - <https://www.facebook.com/help/828417127257368>

Splash 360 demo

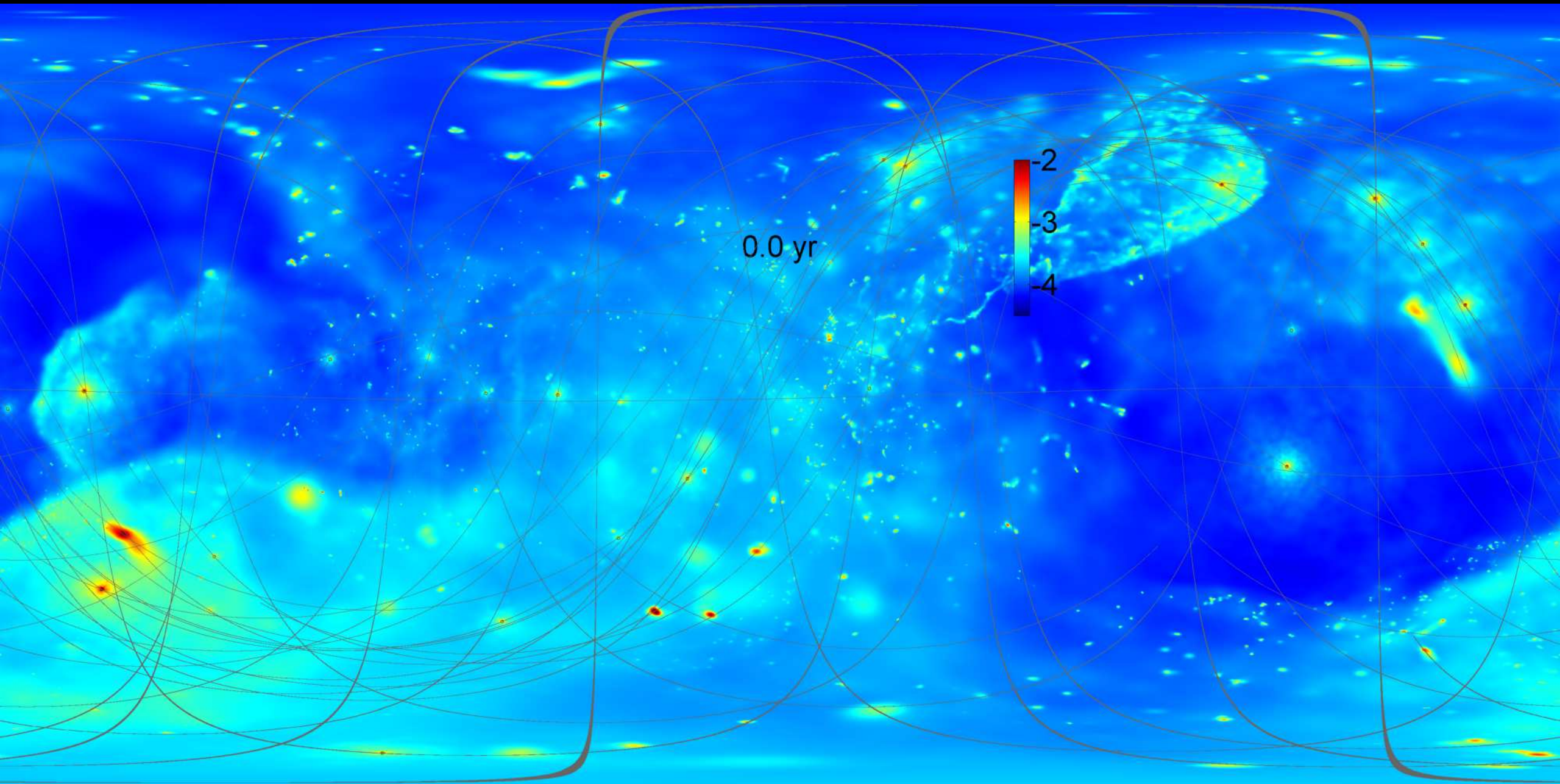
- Latest version of Splash (14 Feb) has “-360” command line option
- `ssplash -360 -r 6 output-file`
 - Executable/360 mode/render column 6/data file
- Only option is output device (/xw, /png, etc); everything else is done
 - Observer is at origin
 - No rotation
 - Rendered quantity is linear
 - Resolution of 1080x540

Splash 360 demo (cont.)

- More advanced: specify origin, rotation, lin/log, limits for rendered quantity, etc.
- Once that is done:
 - 3 (theta)
 - 2 (phi)
 - 6 (rendered quantity)
 - `360image.png/png` (output device)
- Helpful modifications if you make 360° videos a lot:
 - `splash.f90`: comment out `nomenu` option in `case ('360', '4pi', 'fourpi')`
 - `options_page.f90`: prompt for `papersize_x` (i.e. resolution) in `defaults_set_page_360`

Tips

- Poles are distorted
 - Make lines/shapes/text thicker/wider at poles: $1/\sin(\text{polar angle})$



Tips

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- Smooth animation requires 24fps/30fps
 - Might need to rerun a simulation with higher output frequency
- Viewing region: $90^\circ \times 90^\circ$, so want visually interesting structure on that scale
 - If scale is larger than that (e.g. CoM of binary system, where stars are 180° apart), then movie won't look as good

Others doing 360° videos (need more!)

- Suoqing Ji: “Thermonuclear Explosions in Binary White Dwarf Mergers Driven by Spiral Instability” <https://youtu.be/GIVMwVPFFwA>
“Magnetic field amplified by supernova shocks in turbulence (Google Cardboard Video)” <https://youtu.be/ZYWY53X7UQE>
- Mike Zingale: “latest Castro WD merger 3-d VR rendering” <https://youtu.be/6-39M6VVIOc>
- Jordy Davelaar: Radio emission from Sgr A* (EHT preparation) <https://www.youtube.com/user/ifyreaknl/>
- Brian Kent: Many videos of astronomical data <https://www.youtube.com/user/VisualizeAstronomy> (Kent17)

Future: 3D and 360°?

- 3D requires rendering an iso-surface (no integrated quantities like column density) to the different perspectives of the right and left eye
 - Omni-directional stereo (ODS)
 - <https://developers.google.com/vr/jump/rendering-ods-content.pdf>
- Downside: requires VR goggles to see in 3D

My YouTube Channel

- tinyurl.com/cmpr360video

Other Videos

- Galactic center
 - Press-release movie shown in non-360-degree format
 - Prior versions with orbits of stars and brighter color scale
- Eta Carinae: colliding wind binary from position of secondary star
- Gamma-ray binary: PSR B1259 where pulsar plunges into a severely distorts the Be disk around periastron