Gravispy: Gravitational Simulations in Open Source Software*

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Abstract

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* https://github.com/cjayross/gravispy

I. INTRODUCTION

II. MOTIVATION

III. METHODS

```
def sph2pixel(theta, phi, res=[256,256]):
    x = np.rint((res[0]-1)*wrap(phi)/2/np.pi)
    y = np.rint((res[1]-1)*(1-np.sin(theta))/2)
    return np.array([x, y]).astype(int)


def pixel2sph(x, y, res=[256,256]):
    # phi \in [0, 2*pi]
    # theta \in [-pi/2, pi/2]
    phi = 2*np.pi*x/(res[0]-1)
    theta = np.arccos(2*y/(res[1]-1)-1)-np.pi/2
    return np.array([theta, phi])
```

IV. RESULTS

V. DISCUSSION AND CONCLUSION

FIG. 1. Illustration marking intermediary steps during the image forming process. First, new image is first created as a black canvas. Then, during execution the algorithm used by `apply_lensing` iterates through each pixel of the newly generated image and uses the passed lensing map to determine which pixel from the input should be placed at that location.

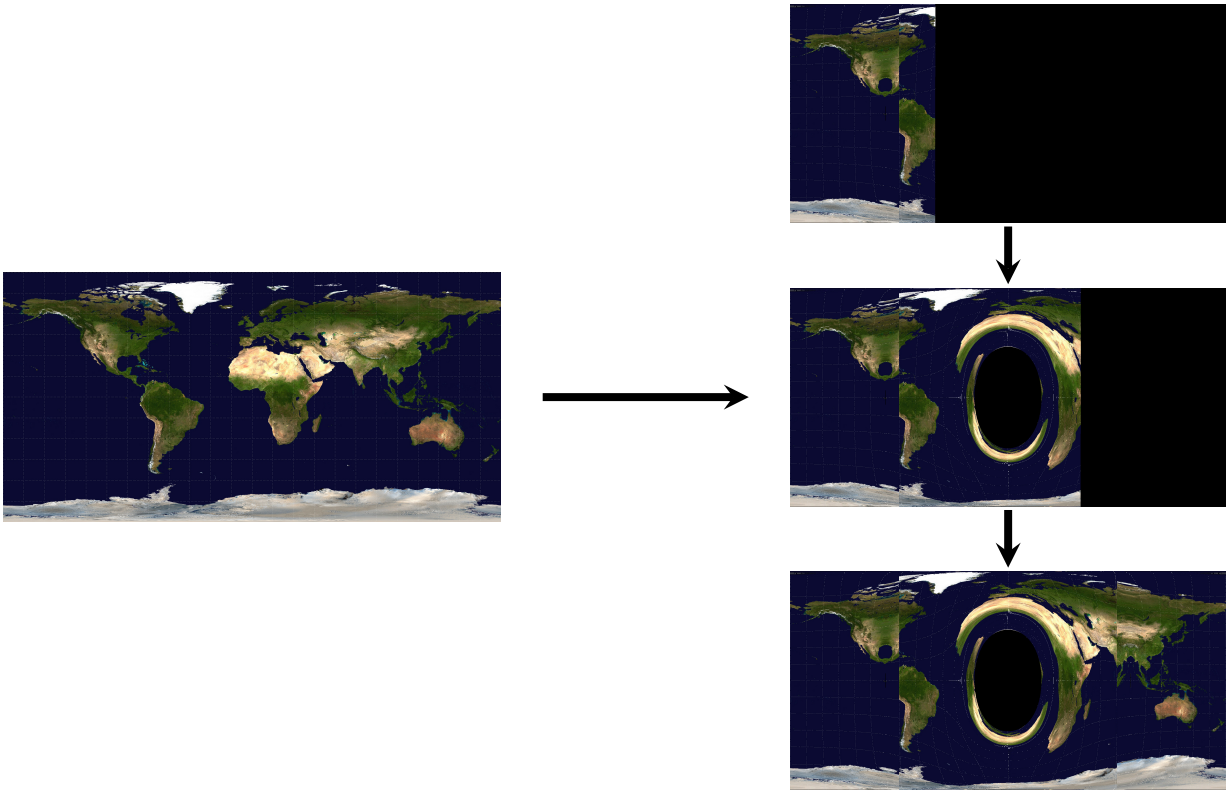

FIG. 2. Sample image used to test the application of a generated lensing map.

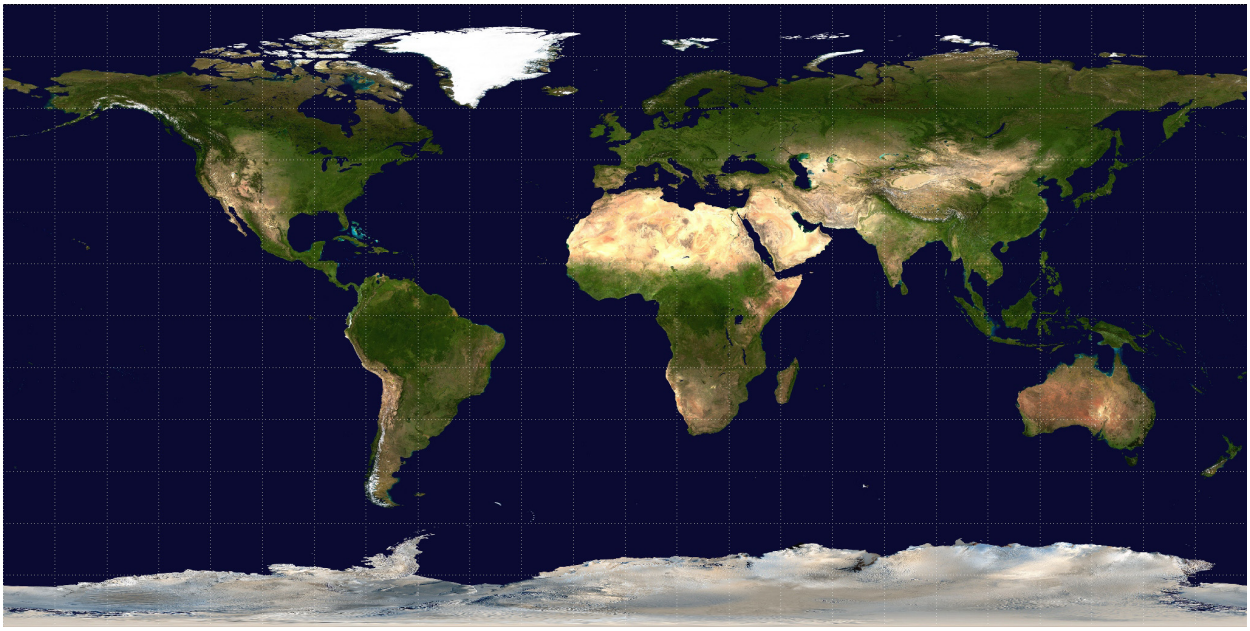

FIG. 3. Final result of applying the explicit Schwarzschild lensing map on the sample image shown in Fig.(2) using a Schwarzschild space-time defined by $M = 1\,\text{km}$ and $R_O = 10\,\text{km}$. In this example, one can easily see the problematic image tearing at the $\pi/2$ and $-\pi/2$ meridians.

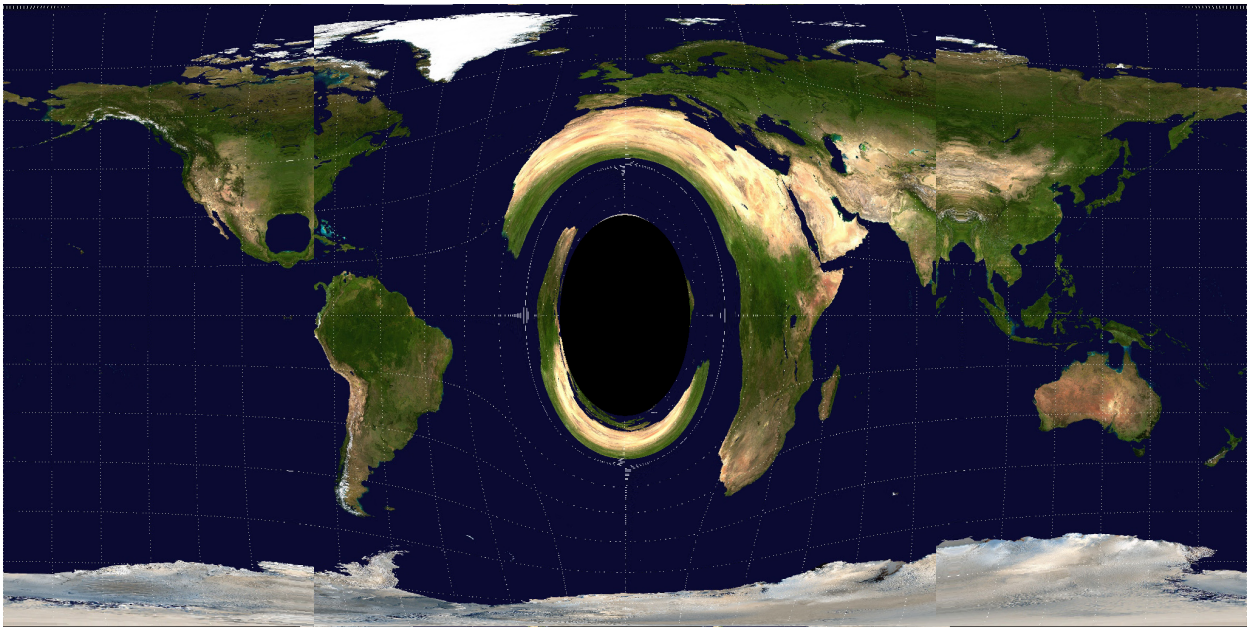

FIG. 4. Second example of a generated Schwarzschild lensing map using the same space-time as in Fig.(3) but at a radius of $R_O = 2.5\,\text{km}$, which is significantly closer to the event horizon. The accuracy of this result hasn't yet been scrutinized, however the overall converging of the observer's sky to the point at $\phi = 0$ is to be expected.

FIG. 5. Comparison between the three levels of approximation in the Schwarzschild lensing equation. The first graph indicates the differences near the singularity, while the latter shows that the amount of error decreases significantly as the radius of the observer increases.