Illusion - A Fabry-Perot Data-Cube Synthesizer

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ABSTRACT

Illusion is a software package designed to synthesize Fabry-Perot data for the Brazilian Tunable Imager Filter (BTFI) project which is developing an instrument for the SOAR telescope at the Universidade de São Paulo in collaboration with several other institutes in Brazil, Canada and France. The Illusion package synthesizes data to help in the development of data-reduction routines, to train observers and to simulate observations in different contexts. The synthesized data are obtained using different kinds of sources located in the telescope's image plane modified by the Fabry-Perot Airy profile. The results are delivered as data-cubes in the FITS format and they have been a powerful resource in the development of new data-reduction routines and for the training of the BTFI's software and observing groups.

1. INTRODUCTION

Illusion is a package developed in the Python language to simulate Fabry-Perot data in the context of the BTFI instrument for SOAR. This project requires the understanding of the interferometry underlying a Fabry-Perot as used as a tunable optical filter.

The synthetic data are recorded as a data-cube, with x,y spatial and z spectral dimensions. They are used to help in the development of a new library of programs to calibrate and reduce the real data, obtained with the instrument.

Illusion simulates data by considering four different kinds of sources (Monochromatic Flat, Monochromatic Image, Multi-spectral Flat and Multi-spectral Image) to aid in different levels and requirements of the simulations.

2. OPTICAL ARRANGEMENT

Currently Illusion uses a classical arrangement for a Fabry-Perot, mounted at the pupil plane within the collimated section, such that interference fringes are formed on the detector con-focal with the image of the sky.
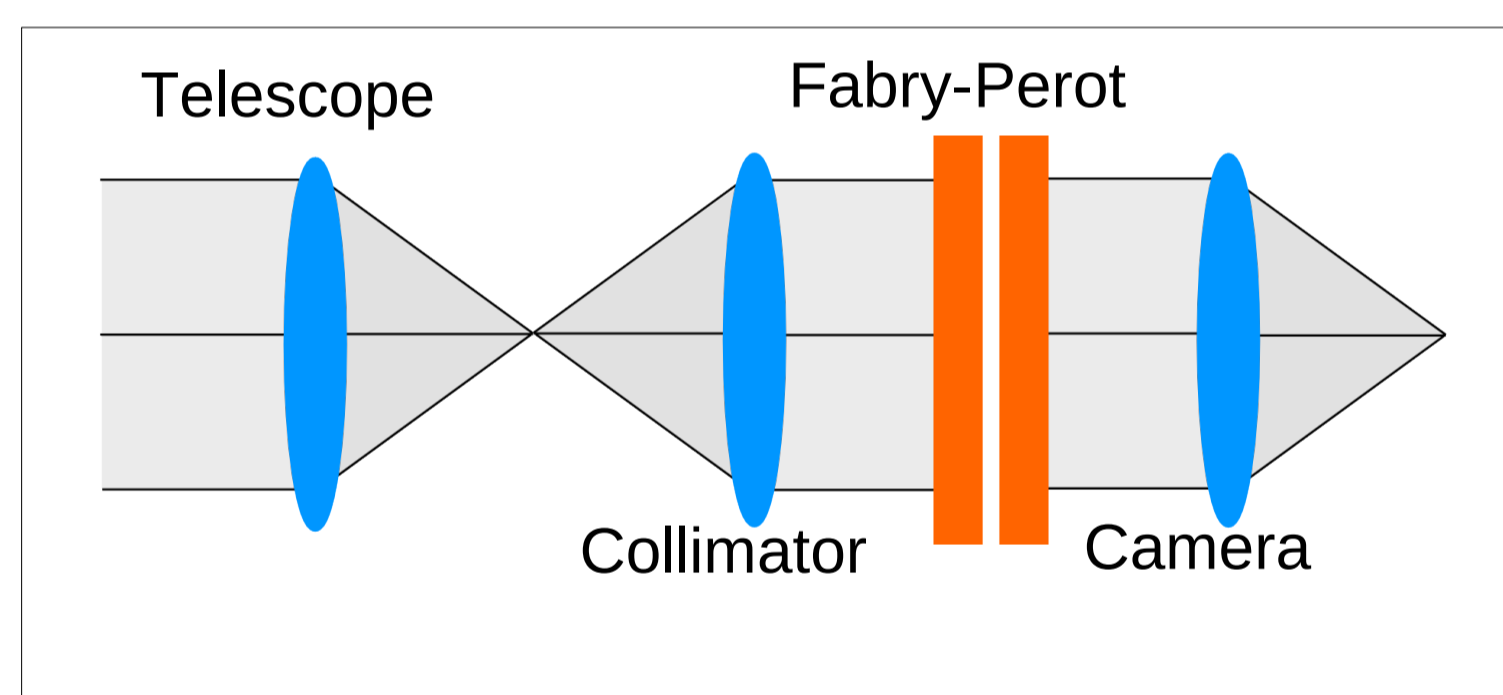
Fig. 1 shows the arrangement that Illusion uses to do the simulations.

Figure 1 – Optical Arrangement

The ellipses in blue represent the optical system lenses (telescope, collimator and camera). The rectangles in orange represent the etalon plates.

3. DATA-CUBE STRUCTURE

The data-cube is stored as a FITS file containing a stack of tunable filter images centered at different wavelengths generally sampled at the Nyquist limit. The X and Y direction in a cube define the spatial information for a given wavelength while the Z direction gives the spectral information for each pixel.
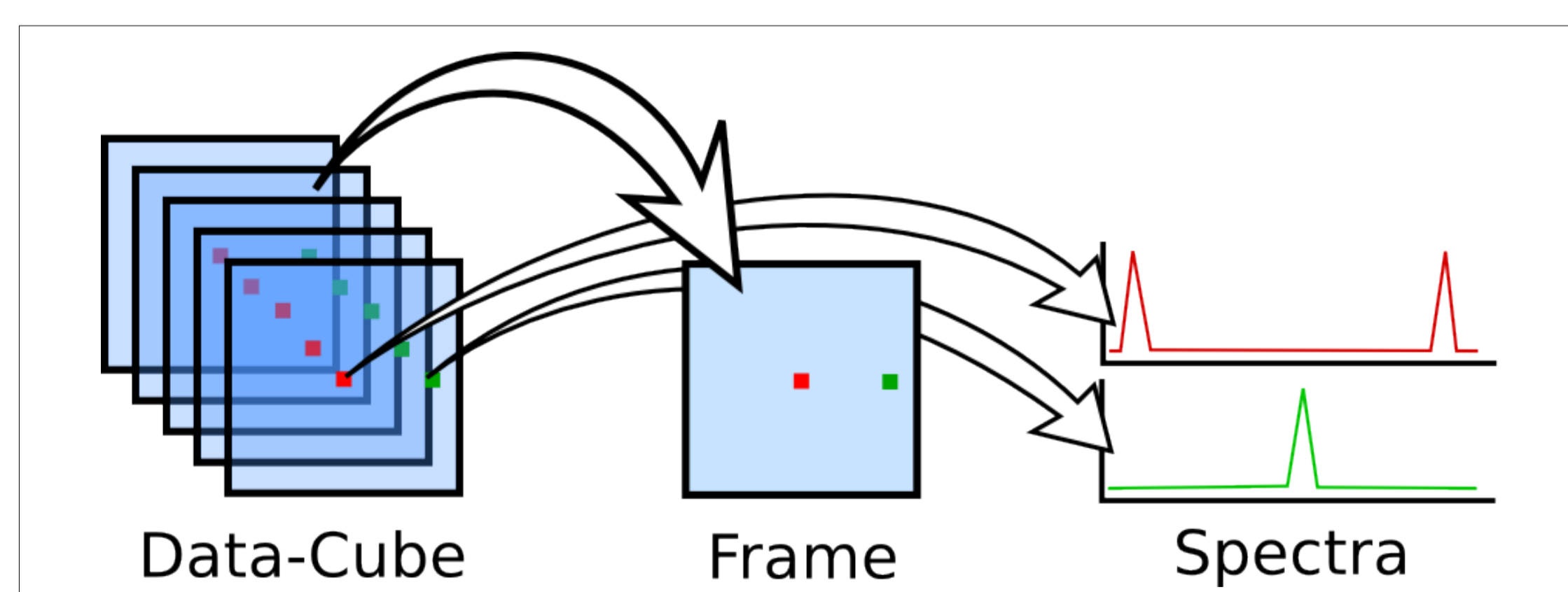


Figure 2 – Data-Cube Structure

4. SYNTHESIZED DATA

The synthesized data shown below shows the results generated by a Fabry-Perot illuminated by a spatially uniform, 550nm monochromatic source at a spectral resolution of 20,000 and with a finesse of 25. The camera's focal length is 350 mm imaging onto a detector having pixels of 16 um.

Monochromatic Flat: the source is a monochromatic even Illuminated screen located at infinity. These images have 1600x1600 pixels.

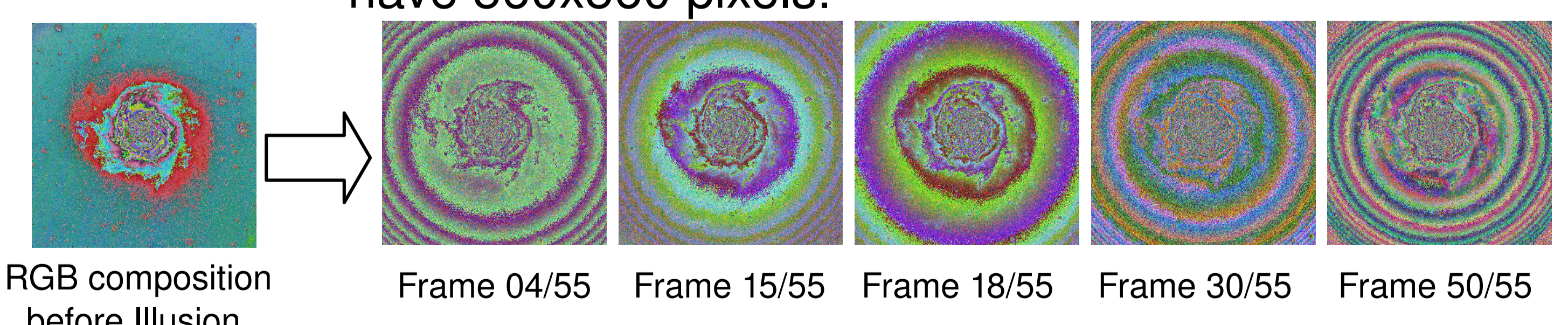

Frame 01/55   Frame 05/55   Frame 10/55   Frame 15/55
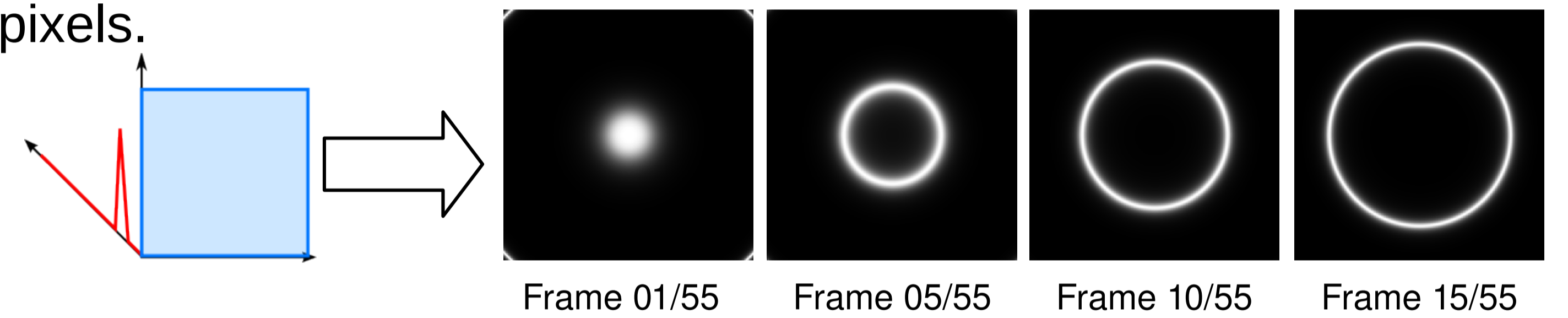
Multi-wavelength Flat: the source is spatially uniform but has three wavelengths of zero width. Here, the blue rings are at 470nm, the green ones are at 550nm and the red ones are at 620nm. As before, each frame has 1600x1600 pixels.

Frame 01/55   Frame 05/55   Frame 10/55   Frame 20/55
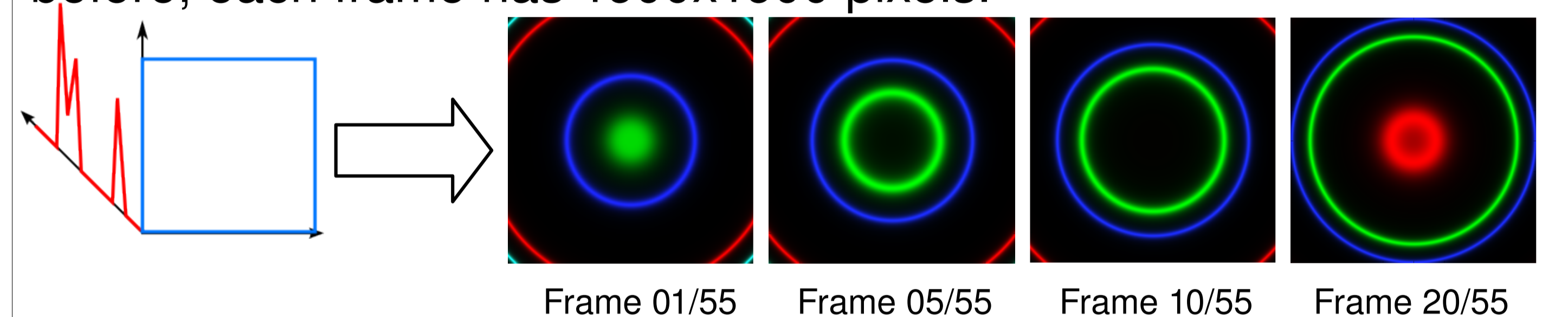
Monochromatic Sky Image: the source is modeled as a monochromatic image located at infinity. In this case, it is represented by the M74 galaxy at 539.7nm imaged by the same Fabry-Perot. Here, each frame has 560x560 pixels.

Original Image   Frame 35/55   Frame 37/55   Frame 39/55   Frame 41/55
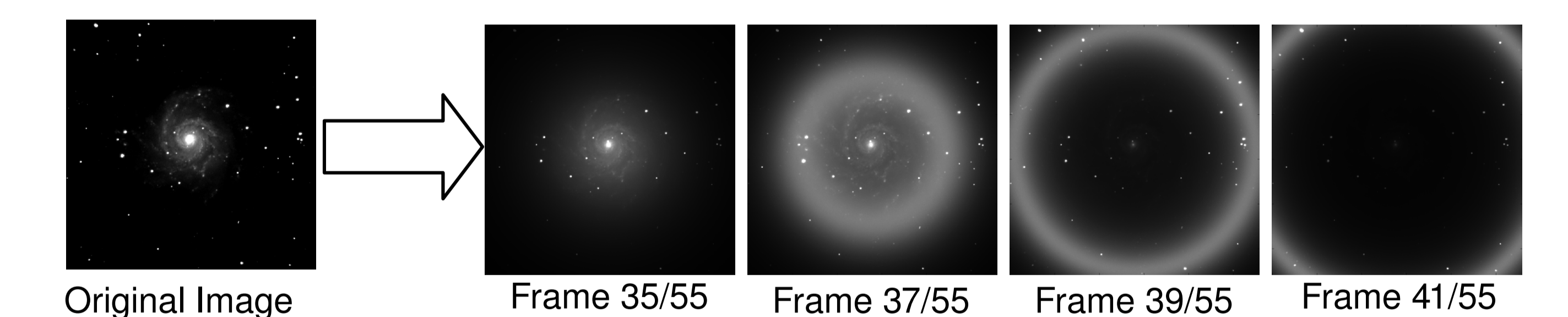
Multiwavelength image: the simulated source is a set of images where each frame is taken at a different wavelength. The RGB images below show M74 in three different wavelengths: 642.5nm (R), 539.7nm (G) and 433.1nm (B). Again, the frames have 560x560 pixels.

RGB composition before Illusion.

Frame 04/55   Frame 15/55   Frame 18/55   Frame 30/55   Frame 50/55

References
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* http://matplotlib.sourceforge.net/
* http://numpy.scipy.org/

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