



# 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 have been an extremely 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 data is recorded as a data-cube, with x,y spatial and z spectral dimensions and is used to help in the development of a new library of programs to calibrate and reduce the 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.

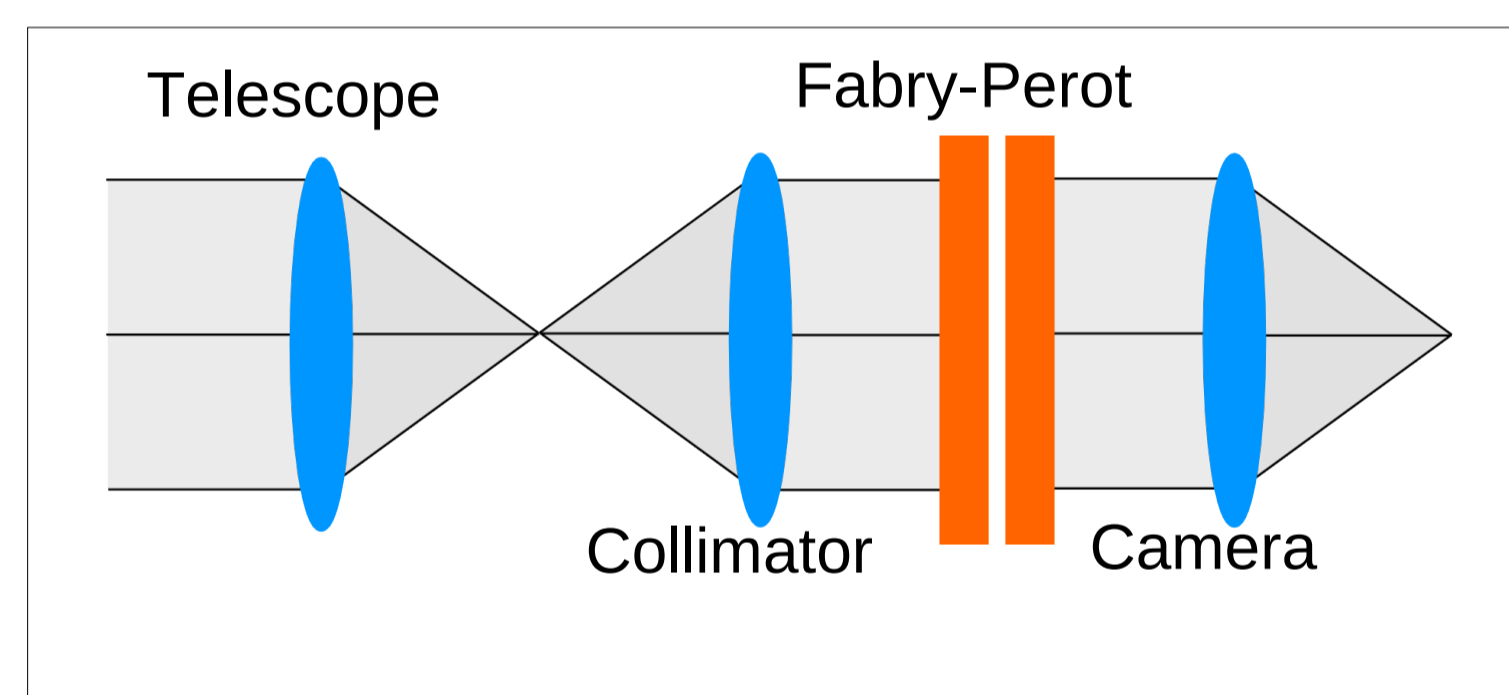


Figure 1 – Optical Arrangement

Fig. 1 shows the arrangement that Illusion uses to do the simulations.

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.

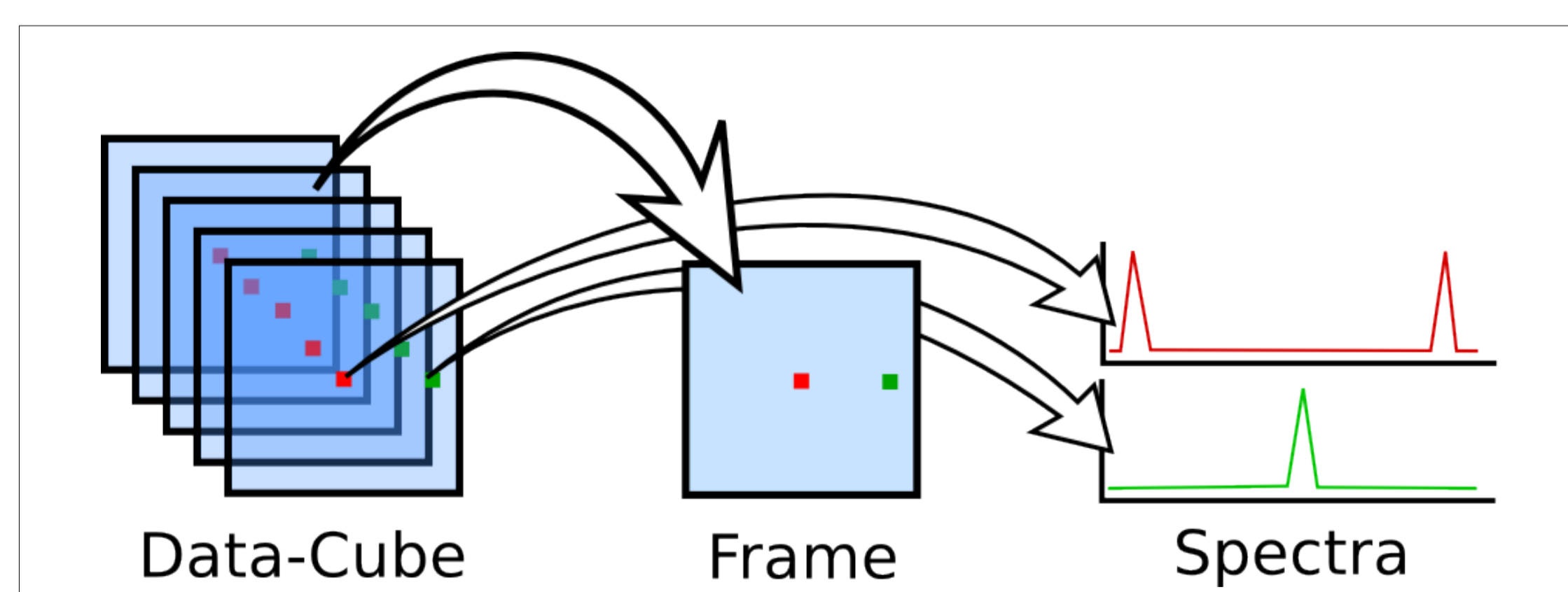
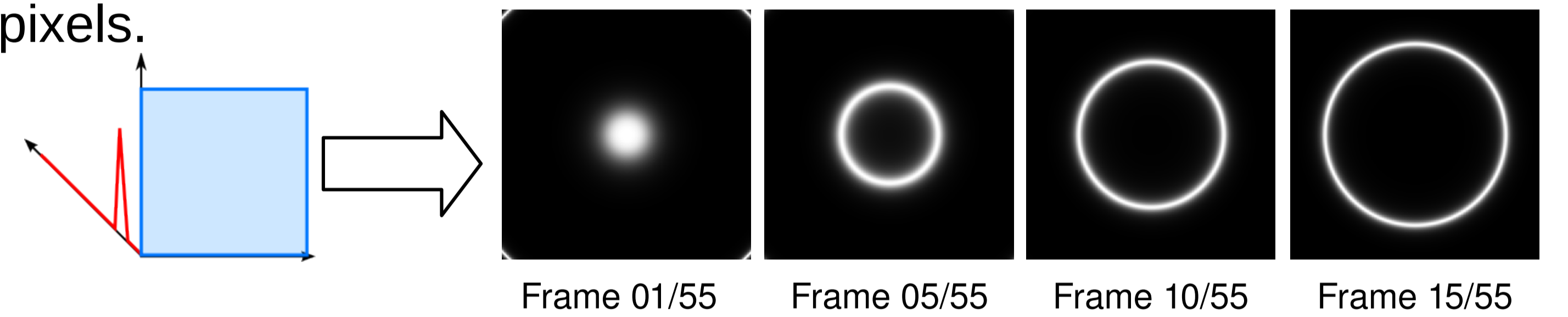


Figure 2 – Data-Cube Structure

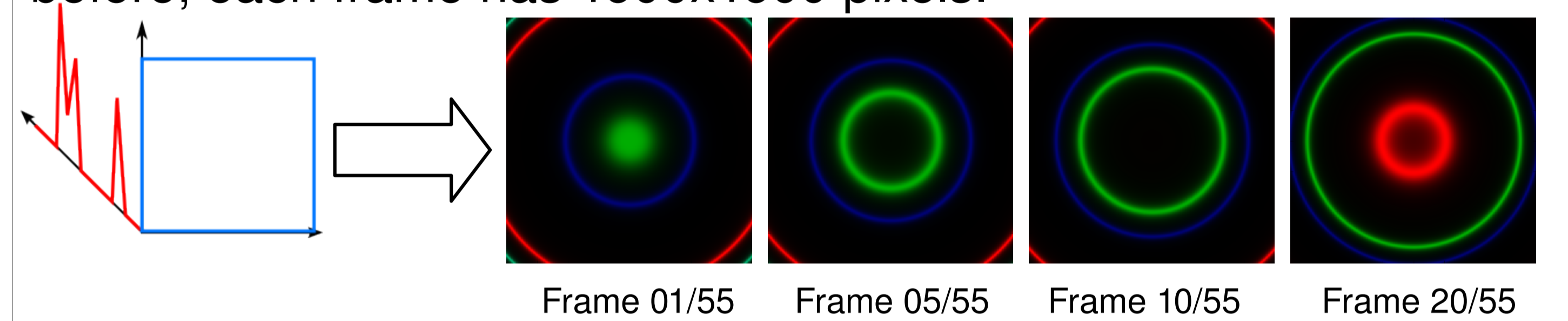
## 4. SYNTHESIZED DATA

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.

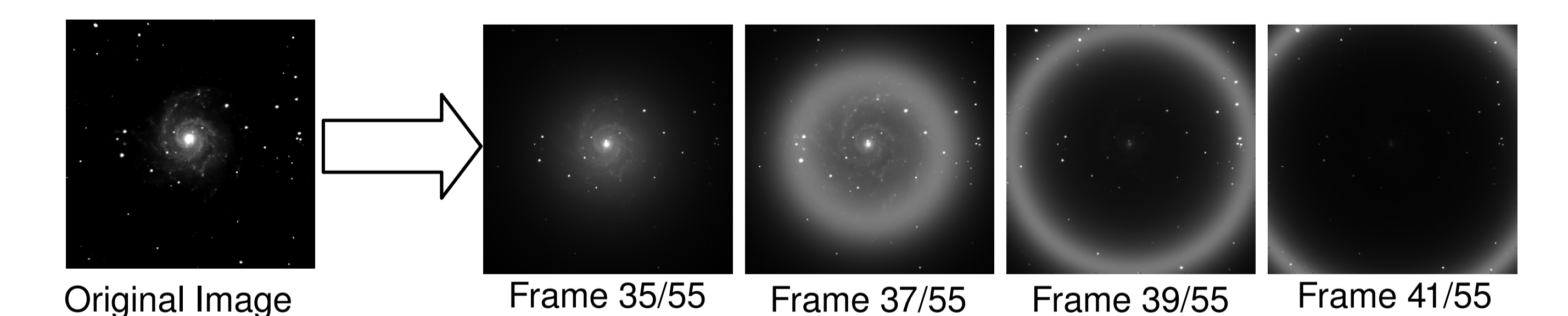
**Monochromatic Flat:** the source is a monochromatic even illuminated screen located at infinity. These images have 1600x1600 pixels.



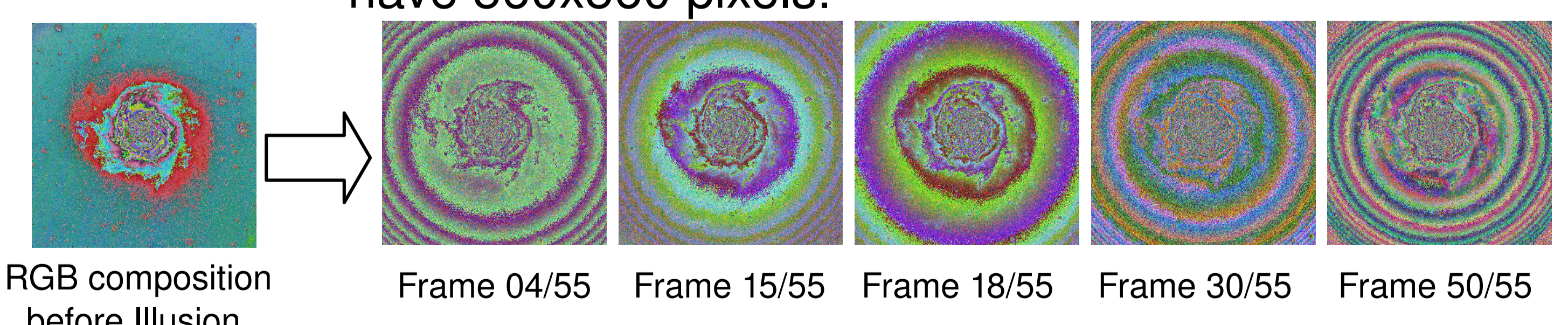
**Multi-wavelength Flat:** the source is spatially uniform but has three wavelengths of zero width. Here, the blue rings are at 470nm, the green ones are at 550nm and the red ones are at 620nm. As before, each frame has 1600x1600 pixels.



**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.



**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.



## References

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\* Lutz, Mark: **Programmin Python**, O'Reilly Media, Eds: O'Brien, Mary, 2006  
\* Barrett, P. E. & Bridgman, W. T. 1999, in ASP Conf. Ser., Vol. 172, ADASS VIII, eds. D. M. Mehringer, R. L. Plante, & D. A. Roberts (San Francisco: ASP), 483

\* <http://matplotlib.sourceforge.net/>  
\* <http://numpy.scipy.org/>

## Acknowledgments

This work is part of the Master's thesis of Bruno Quint and it is supported by CPNQ scholarship (process n.136015/2008-5).

