M42 Analysis

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- **Instrument Used:**

  8-inch telescope with KAF0401E CCD in SBIG ST-7XE Camera.

- **Theory: -**

  The Orion Nebula (also known as M42/NGC 1976) is a diffuse nebula situated in the Milky Way, being south of Orion's Belt in the constellation of Orion. Its coordinates are $05^h\ 35^m\ 17.3^s$, $-05°\ 23'\ 28''$. The image is taken in blue, green, red and H_alpha. The distribution of hydrogen can be seen well by the emission from them in H_alpha. Thus, it is used to map the gas along with the stars via the other filters.

- **Procedure: -**

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crutil> imstat
List of input images (bias_mean_combine.fits): *.fits
#               IMAGE      NPIX      MEAN    STDDEV       MIN       MAX
          bias_1.fits    390150     103.8     7.142        73.       137.
          bias_2.fits    390150     106.1      7.15        77.       140.
          bias_3.fits    390150     104.9     7.135        75.       149.
          bias_4.fits    390150     106.5     7.148        79.       144.
          bias_5.fits    390150     105.9     7.144        75.       144.
       dark_5s_1.fits    390150     104.2     7.156        74.       162.
       dark_5s_2.fits    390150     107.4     7.176        76.       154.
       dark_5s_3.fits    390150     106.5     7.159        80.       145.
       dark_5s_4.fits    390150     106.1      7.17        77.       168.
       dark_5s_5.fits    390150     107.3     7.171        80.       147.
      m42_b_5s_1.fits    390150     132.3     169.7        80.     13156.
      m42_b_5s_2.fits    390150     141.2     153.6        89.     11257.
      m42_b_5s_3.fits    390150     142.5     168.5        93.     12990.
      m42_b_5s_4.fits    390150     142.1     166.7        90.      9493.
      m42_b_5s_5.fits    390150     142.5      169.        93.     12272.
      m42_g_5s_1.fits    390150     149.4     159.8       103.     11375.
      m42_g_5s_2.fits    390150     145.4     155.5        97.     10864.
      m42_g_5s_3.fits    390150     149.4      149.       104.     11043.
      m42_g_5s_4.fits    390150     147.1     150.5       103.     11698.
      m42_g_5s_5.fits    390150     146.9     140.8        97.     10910.
     m42_ha_5s_1.fits    390150     125.5     45.44        82.      1245.
     m42_ha_5s_2.fits    390150     124.2     48.35        80.      1240.
     m42_ha_5s_3.fits    390150     126.2     49.54        80.      1278.
     m42_ha_5s_4.fits    390150     127.7     50.52        83.      1266.
     m42_ha_5s_5.fits    390150      128.     51.93        81.      1304.
      m42_r_5s_1.fits    390150     166.6     188.8        96.     12790.
      m42_r_5s_2.fits    390150     166.4     192.4        98.     12732.
      m42_r_5s_3.fits    390150     166.5     192.3        99.     13347.
      m42_r_5s_4.fits    390150     166.2     191.3        97.     13391.
      m42_r_5s_5.fits    390150     164.5     195.5        95.     13683.
```

Fig 1: It shows the list of images taken for this analysis.

1. Pole star alignment was done by setting the telescope stand in the north-direction.
2. Two-star alignment was done.
3. The Grab feature in CCDOps was used for capturing the images. Since there was an issue of size mismatch and the presence of ring like features while doing flat-fielding, the division of other images with flats is not done.
4. We took 5 frames each of bias, dark, and in each filter naming b, g, r, H_alpha respectively of 5 sec.
5. The dark frame is taken by keeping the shutter close and then taking grab of 5 sec and in bias it is set to 0 sec but it automatically set to 0.12 sec (lowest time).
6. The subsequent analysis is done in IRAF.
7. Using task rename, all files were changed from *.fit to *.fits extension.
8. Cosmic ray removal is done using the task "noao-imred-crutil-cosmicrays".

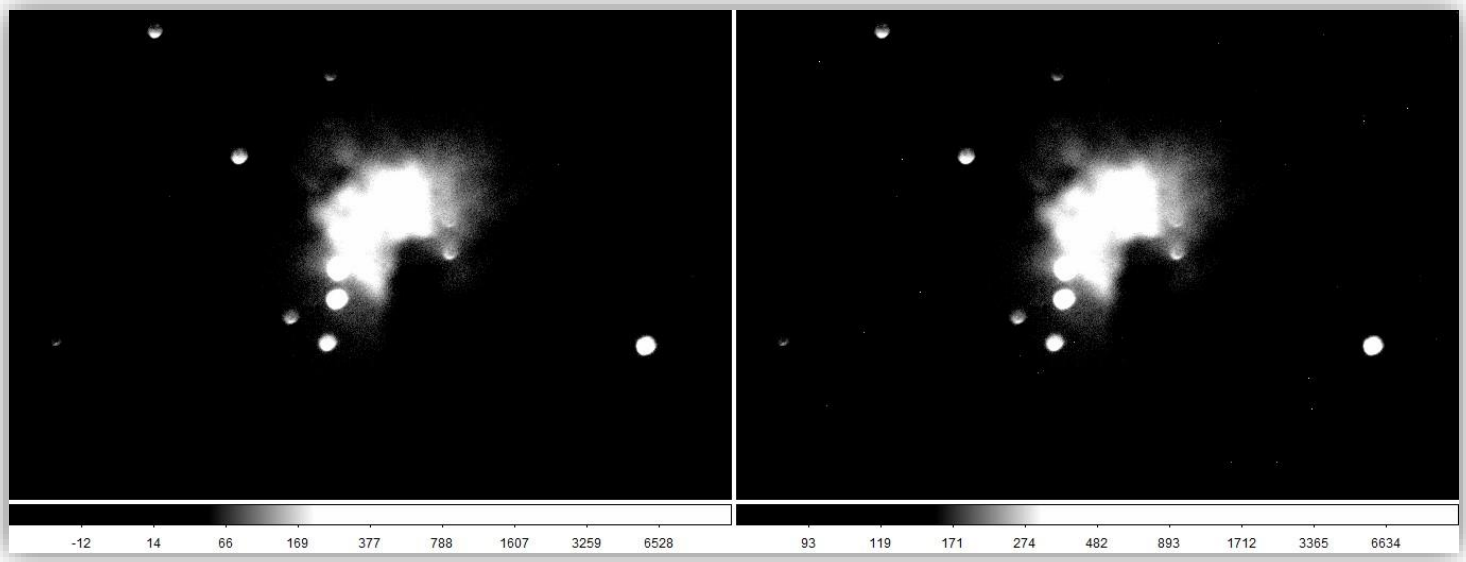

Fig 2: Image "m42_b_5s_1.fits"showing before and after cosmic rays removal.

9. Master bias and master dark is created using the task "imcombine".
10. Master bias is subtracted from all frames including the master dark.
11. Then the master dark is subtracted from the filter frames of M42. List is made using "!ls *.fits>list1" and manually removed those that are not required. Similar process is followed wherever we have to do operation on bulk of images.
12. To view the image, DS9 is opened using "!ls ds9 &" in IRAF.
13. In each image the location of one bright star is selected by pressing c in DS9. It will keep on writing the X,Y, Value in another window. This task is repeated in all images and then the file is saved as txt for further analysis.
14. To check for rotation the angle difference using arctan(Y/X) is done to compare the angle of the selected bright source for reference. Upon comparison the angle was deemed to be ignorable. And thus, only image shifting was done.

15. Using the task “imshift” the images were shifted and then using the task “imcombine” the average_b, average_g, average_r, average_H_alpha fits file was made.
16. Again in DS9, in the option “frame” the rgb is selected and blue, green and H_alpha (in red) is opened and scaled properly for a good combined image.
17. Issue:- We initially took the data in our first lab but half of the files were corrupt, in some there was some jittering. Hence after the end of the all labs we took the data. This time no such issue was there. But the images were not properly focused due to which in all images the sources looks like a blob rather than a small spread.

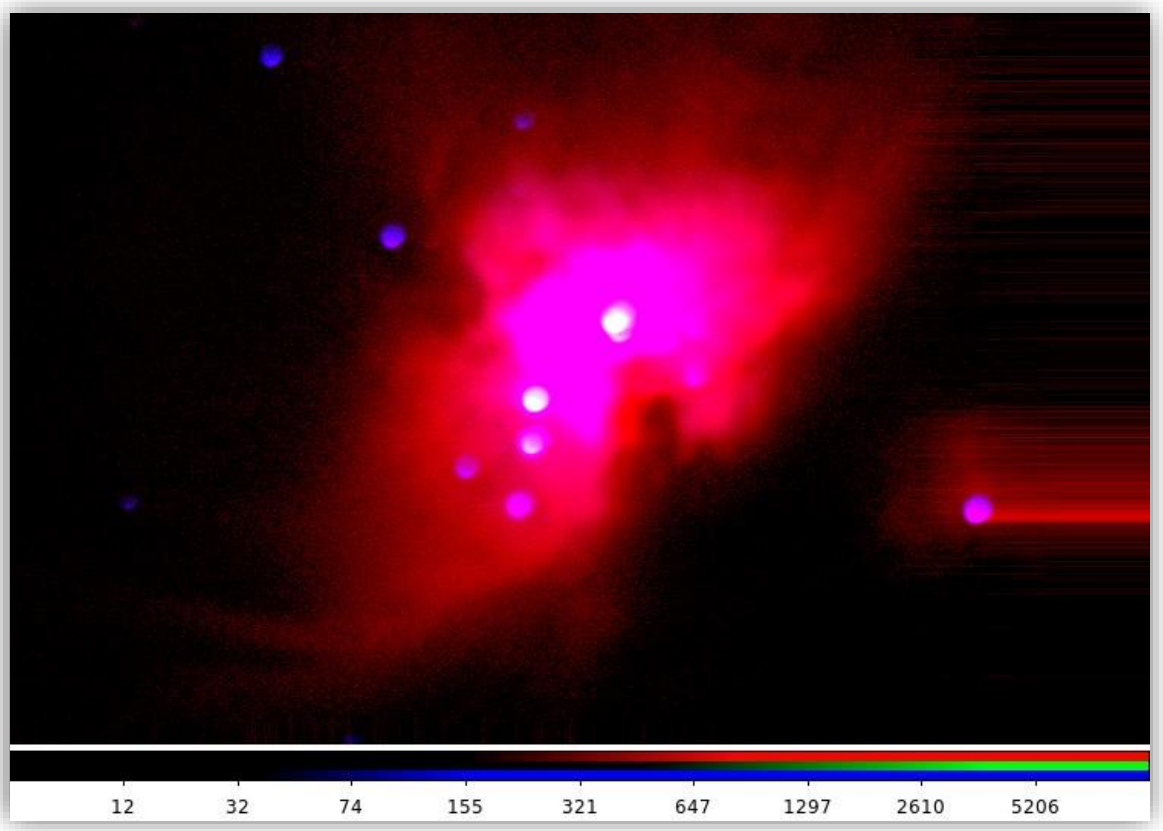

Fig 3: It shows the final composite image of M42.

Conclusion: -

- We were successfully able to make the color composite image from the images taken in 4 filters.
- We got the chance to apply the IRAF techniques learnt in the previous semester for the analysis of the data taken by us. That itself is interesting.
- Even though there are some issues, proper steps are taken so that no further problem arises due to data analysis.