Southern African Large Telescope

Title: **Scatter light at SALT**

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ABSTRACT

In this report I present results of study of scatter light of the optical systems SAC and RSS at SALT. These results show that ***scatter of light exists in both optical systems****. For this reason it is possible to suggest, that SAC cleaning will change the current scatter light pattern and the total scatter will be smaller.*

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1 Introduction

As a result of SALT+RSS long-slit observations we know that scatter light exist and its input could reach up to 15–20% for the outer parts of extended objects (Katkov, et al., 2019). Scatter light is detectable as a wide wings of the central point-like source. Some very important questions related to this problem are:

1. Which optical system mainly is responsible for that: SAC or RSS?
2. Could it be that large enough scatter light exist in both of them?

I try to answer these questions in the current report.

2 General idea

The general idea of the test is very simple. Light from the point source (any star) goes through SAC first and RSS second:

1. In case we detect this light passing through RSS long-slit with RSS detector, we are not able to separate input from both these systems.
2. However, if we first, observe any star with regular long slit and repeat this observation immediately after, but will close the whole long-slit except its only small central part to get light from the star itself, the final result at RSS detector will be **different** in three different scenarios:
   - **A** *If scatter exist in BOTH optical systems* – in this case some part of the scatter light goes from SAC will be blocked along the whole closed long-slit and final wings will be fainter;
   - **B** *If scatter MAINLY exist in SAC* – in this case practically the whole scatter light will be blocked and final wings will be **drastically** fainter;
   - **C** *If scatter MAINLY exist in RSS* – in this case practically nothing will change, because the main source of the scatter light still passing through RSS's long-slit.
3. Additionally, if we observe after that the same star using "dashed line" long-slit consist of cut–not cut–cut–not cut... structure, the final result at RSS detector will be as well **different** in these three scenarios:
   - **(A)** *If scatter exist in BOTH optical systems* – it will be the same as with regular long-slit for open (cut) parts and coincide (be fainter) with **A** for non-cut parts;
   - **(B)** *If scatter MAINLY exist in SAC* – the flux will be drastically fainter in all non-cut parts;
   - **(C)** *If scatter MAINLY exist in RSS* – in this case practically nothing will change, because the main source of the scatter light still passing through RSS's long-slit.

I will call these three scenarios as **(A)**, **(B)** and **(C)** hereafter.

3 Observations

To check the general idea above I suggested to make three types of observations following to each other:

Step 1: Observe bright enough star with RSS long-slit of 2" width and length of 8';

Step 2: Immediately after that, observe the same star with long-slit 2"×30" that was laser-cut in the carbon plate;

Step 3: Immediately after that, observe the same star with "dashed line" long-slit: 2" width and consist of (30" cut)–(30" not-cut)–(30" cut)... up to 4' in each direction from the center of the field.

Two masks were cut with great help of **Christian and Ros**. Thanks a lot!!!

The final observations were done by SA **Petri Vaisanen** :-) on 2019 September 20. Thanks a lot as well!!!

4 Following Analysis

The final analysis was done in the very simple mode, where data were averaged along the spectral direction for each amplifier. The result of my analysis for one amplifier is shown in Figure 1. First, I plotted with **magenta color** the Gaussian with FWHM=2.1 as an example of on-sky PSF for these observations. This is **non-scattered** light distribution. The light distribution of the star observed with regular long-slit of 2" width and length of 8' is plotted with **black color**. The light distribution of the star observed with long-slit 2"×30" is plotted with **red color**. The light distribution of the star observed with "dashed line" long-slit is plotted with **blue color**.

I am not sure that all three observations were well centered, since observations with regular long-slit and long-slits laser-cut are very different (thanks to Petri once more!). For that reason all three distributions are normalised by maximum to each other. As it is easy to see the black wings (regular long-slit) are brighter of the red wings (long-slit 2"×30") and blue wings ("dashed line" long-slit) are similar to the red wings in non-cut areas and are similar to black wings in laser-cut areas.

Altogether, these data support scenario (A).

We need to understand that in our case equation:

$$S_{\rm obs} = F_\star \cdot {\rm PSF}_{\rm seeing} * {\rm PSF}_{\rm scat}, \tag{1}$$

where $\rm PSF_{seeing}$ is the point spread function caused by atmospheric perturbations, $\rm PSF_{scat}$ – the full PSF of the light scattering in the telescope plus instrument setting, $F_\star$ is a total stellar flux at a given wavelength, and * is the convolution operator, could be changed into the new form like:

$$S_{\rm obs} = F_\star \cdot {\rm PSF}_{\rm seeing} * {\rm PSF}_{\rm scat\_SAC} * {\rm PSF}_{\rm scat\_RSS}, \tag{2}$$

where PSF_{scat_SAC} is the light scattering in SAC and PSF_{scat_RSS} is the light scattering in RSS.

It is very hard to separate these two convolutions, but from the general point of view the second convolution (inside of RSS) has to move previously scattered light (inside of SAC) in the out-of-center directions. This effect could be seeing in Figure 2, where I have plotted ratio between distribution plotted with **black color** and the distribution plotted with **red color**. The ration at the center is very close to 1. It is possible to see that these two observations were done with small shift along the slit, but the main effect is that the ratio **increases** from the center of the slit to edges that could be explained as a "scatter of scattered light" effect. Since signal is faint at the edges, I smoothed it slightly with 10" window. It looks to me that negative and positive directions show slightly different pattern, but it is very hard to explain such an effect. Could it be that our regular long-slit of 2" width has systematic difference of the width?

5 Conclusions

These results show that scatter exist in both optical systems. For this reason it is possible to suggest, that SAC cleaning will change the current scatter light pattern and the total scatter will be smaller.

References

Katkov I. Y., Kniazev A. Y., Kasparova A. V., Sil'chenko O. K., 2019, MNRAS, 483, 2413

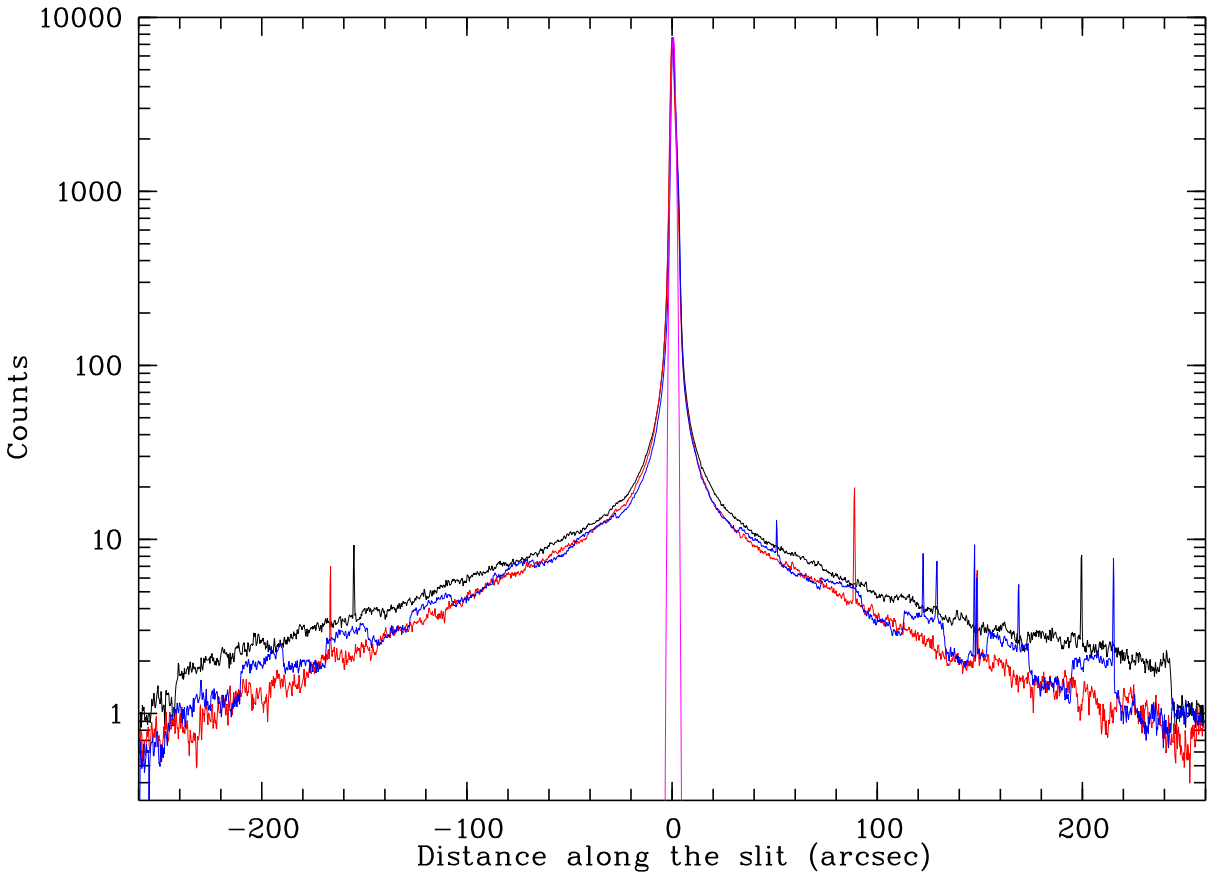

Figure 1: The distribution of the scatter light along the long-slit. The center of observed star is located at position 0 (zero). The PSF (Gaussian) of FWHM=2.1" is plotted with **magenta** color as **non-scattered** light distribution. The light distribution of the star observed with regular long-slit of 2" width and length of 8' is plotted with **black** color. The light distribution of the star observed with long-slit 2"×30" is plotted with **red** color. The light distribution of the star observed with "dashed line" long-slit is plotted with **blue** color.

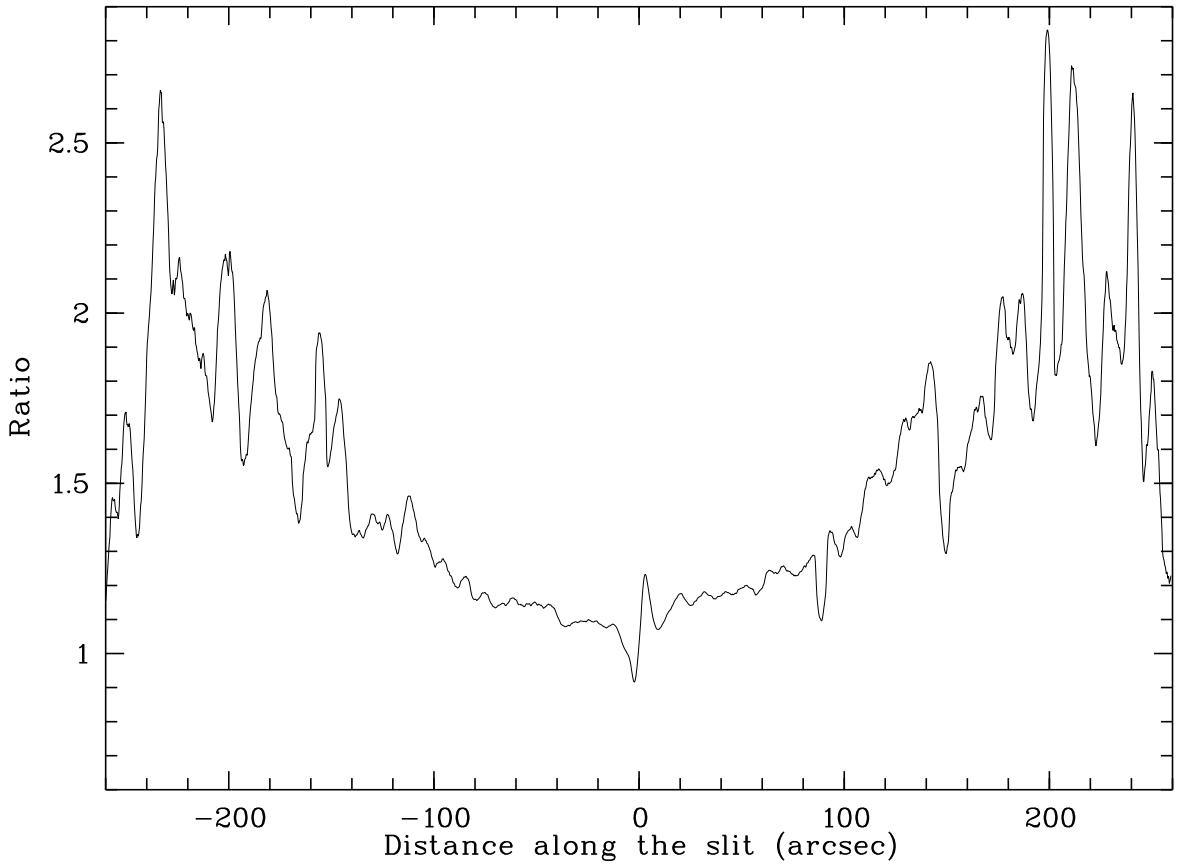
2.5
2
1.5
1
Ratio
−200
−100
0
100
200
Distance along the slit (arcsec)

Figure 2: AAA