



Miniature Atomic Source Manual

V2.0

Revision date 20/10/2025

Contents

Contents.....	2
Introduction.....	3
System alignment.....	3
Installation of the MAS.....	4
Setting up the alignment system.....	8
Alignment of the heating laser.....	9
Cracking the MAS.....	11

Introduction

The Miniature Atomic Source (MAS) is a high-efficiency fused silica laser-heated atom source. The atomic flux can be controlled by adjusting the optical power of the heating laser, within a recommended operational range. Due to its high thermal efficiency and homogeneous glass construction, the MAS can be run continuously, producing neutral atom densities suitable for ion trapping while presenting a negligible heat load.

System alignment

To ensure alignment between the mounted MAS and ion trap, we can provide an alignment module which has the same outer envelope as the MAS, Figure 1. Light can be propagated through the fibre of the alignment module to show the expected propagation direction of the atomic flux, Figure 2. After the mounting direction is verified, the alignment module can then be replaced with the MAS.



Figure 1: The packaged alignment module.

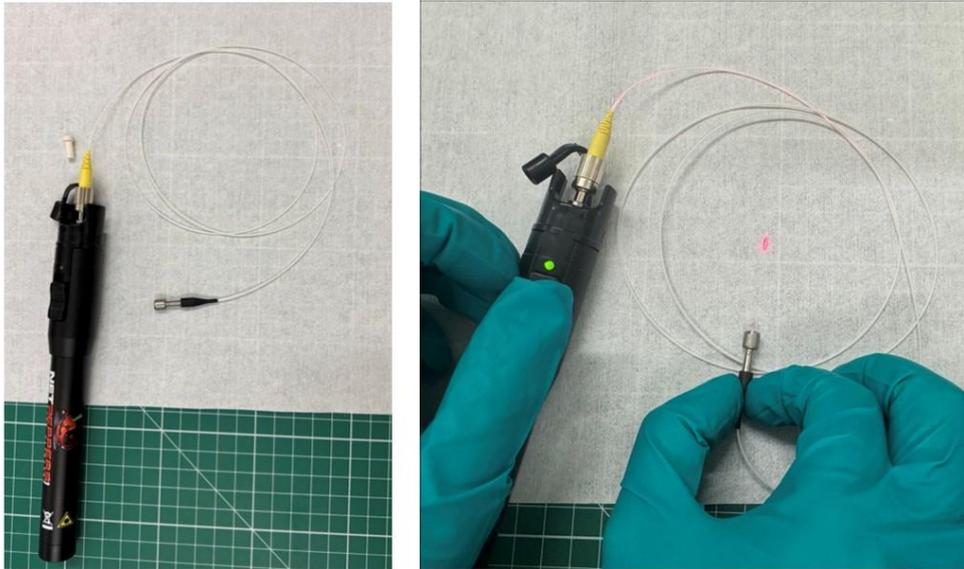


Figure 2: Connect a visual fault locator (630nm) onto the alignment module for a visual representation of atomic flux [Left-side shows connection, Right-side shows red laser output spot].

Installation of the MAS

Warning: it is vital to limit exposure to oxygen and moisture-vapour to protect the function and longevity of the MAS. Therefore, we recommend performing the handling steps within an inert glovebox environment (oxygen and moisture levels <20ppm).

The MAS is supplied in a custom transport assembly to maintain an inert environment during shipping and storage at your facility until used, see Figure 3. The MAS is secured in a flexure mount connected to the CF40 flange (left-hand side) and the angle valve (right-hand side) is closed to protect the inert environment.



Figure 3: The transport assembly. CF16 port available at bottom for inert purge gas connection.

OPTIONAL: For prolonged storage, you can connect an inert purge gas to the CF16 port (shown at the bottom in Figure 3). Once the purge gas is connected and circulating, you may then open the angle valve to purge the zone containing the MAS.

The MAS is supplied UHV clean and ready for installation. We recommend wearing protective gloves when opening the transport assembly and only using clean metal tweezers when handling the MAS. We also suggest using a fresh sheet of Ultra High Vacuum grade aluminium foil to act as a clean work surface.

To disassemble the packaging:

1. (Optional) Connect inert gas supply to the CF16 port, once purge gas is flowing open the angle valve to flood the zone containing the MAS.
2. Rotate the transport assembly upright to expose the CF40 flange bolt heads and loosen using a 10mm spanner, Figure 4. (The assembly may be rested on the angle valve to facilitate handling).
3. Lift off the CF40 flange vertically and turn over to reveal the MAS mounting assembly, Figure 5.
4. Place the CF40 flange assembly-side up on a clean work surface, then unscrew the aluminium spacer using an 8mm spanner, Figure 6.
5. Detach and set aside the aluminium spacer, Figure 7.
6. Lift off the 5-pronged titanium flexure mount with tweezers, then turn over and hold just above a clean surface.
7. Gently press out the MAS using the flat edge of a second pair of tweezers onto the clean surface, Figure 8. The MAS is now ready to be picked up and loaded into your setup.



Figure 4: Transport assembly oriented vertically while bolts are being loosened.

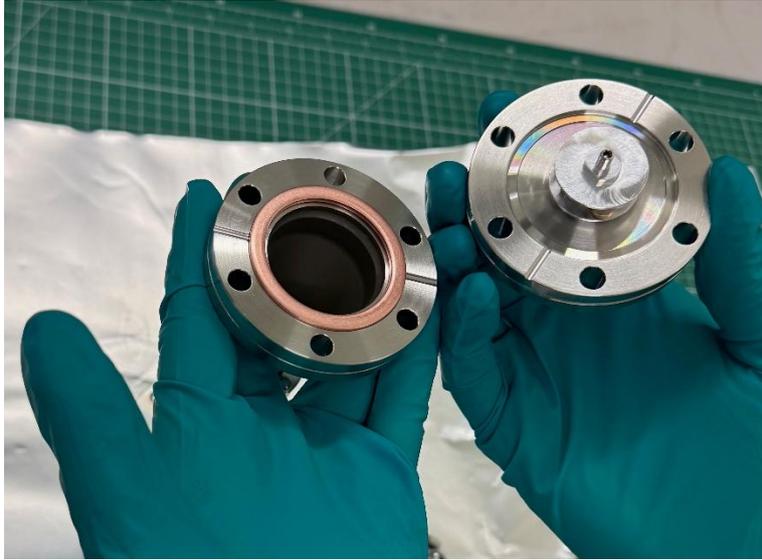


Figure 5: Removal of CF40 flange to reveal MAS mounting inside (right).



Figure 6: Removal of aluminium spacer (above the MAS)



Figure 7: The MAS (face down) held in 5-pronged flexure mount on CF40 flange.



Figure 8: MAS (front face up) being pressed out of the 5-pronged flexure mount.

Setting up the alignment system

With the vacuum system closed and under vacuum, the heating laser must be aligned with the heating aperture on the rear surface of the MAS.

The recommended alignment system shown in Figure 9 consists of the heating laser, a beam splitter, a camera lens, a camera, and an objective lens.

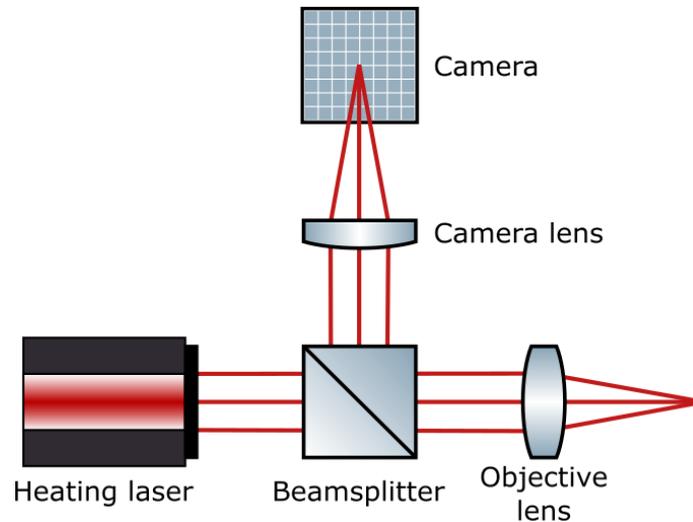


Figure 9: Schematic of the alignment system

The spot size ($1/e^2$ diameter) of the heating laser should be approximately $s = (25 \pm 5)\mu\text{m}$ in diameter to fit comfortably into the $50\text{-}\mu\text{m}$ aperture hole of the MAS.

The required focal length can be calculated from the collimated beam diameter d using

$$f = \frac{\pi s}{4\lambda} \sqrt{d^2 - s^2},$$

where λ is the wavelength of the heating laser. If the heating laser is delivered by a fibre with numerical aperture NA_{fib} and is collimated by a lens with focal length f_{col} , the collimated diameter will be given by $d = 2f_{\text{col}}\text{NA}_{\text{fib}}$. Table 1 lists the recommended range of focal lengths for various collimated beam diameters, assuming a heating laser wavelength of 780nm .

Collimated diameter / mm	2	4	6	8	10
Focal length / mm	50 ± 10	100 ± 20	150 ± 30	200 ± 40	250 ± 50

Table 1

The objective lens is placed on a 3-axis translation stage, with the transverse degrees of freedom (normal to the heating beam propagation direction) requiring high positional accuracy whilst the longitudinal translation (focal distance) can be coarse.

Note that mounting the beam collimation optics on a translation stage and keeping the position of the objective lens fixed will not provide sufficient degrees of freedom to align properly to the MAS.

A beamsplitter (90:10 or similar) is placed between the laser source and the objective lens, with most of the power transmitted towards the MAS. The beamsplitter then directs a portion of the back-reflected light from the object onto a camera.

The spare port on the beamsplitter can be used for monitoring laser heating power delivered to the MAS, with appropriate calibration.

1. Collimate the heating laser light (factory aligned collimators should be used where possible for best collimation).
2. Adjust the camera lens such that the camera is infinity-focussed. Ensure that an object placed >100m away appears sharp on the camera (note that laboratory-scale distances are not sufficient to ensure infinity-focus).

Following steps 1 and 2 ensures that the object plane of the camera coincides with the heating laser focus, and from this point onward neither the collimation lens nor the camera lens should be adjusted.

The preparation of the alignment system is now finished, and it can be moved to the target vacuum system to align the heating laser onto the MAS.

Alignment of the heating laser

1. Illuminate the MAS with a diffuse light source and position the alignment system such that its back surface is imaged sharply onto the camera, Figure 11.

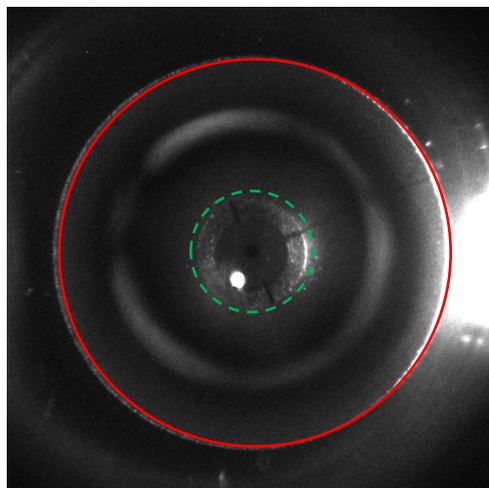


Figure 11: The image of the rear surface of the MAS should clearly show the alignment crosshair in focus, seen at the centre of the above image within the dashed green ring. The laser beam can be seen in the lower left region of the alignment crosshair. The 'outer annulus' is circled in red.

2. Turn on the heating laser at sufficiently low power to avoid saturating the camera sensor. This power will be well below the MAS operating power and may be below the lasing threshold of the laser diode.
3. Adjust the transverse position of the objective lens until the heating laser spot lies within the crosshair region of the MAS. Note that this adjustment will appear on the camera as a movement of the MAS rather than the heating laser; this behaviour is expected from the construction of the optical system.
4. Verify that the spot size is consistent with the target spot size ($\sim 25\mu\text{m}$) by counting the illuminated pixels and multiplying this number by the pixel size and the magnification of the imaging system. This will give inconsistent results if the camera is saturated.
5. Further adjust the transverse position of the heating laser spot to enter the rear aperture of the MAS (in the centre of the crosshairs), where the back-reflected power should drop significantly.

Even with perfect optical alignment, the spot will not fully disappear, but a distinct diffraction pattern will be visible. At high powers, this should become a distinct ring of laser light, as shown in Figure 12.

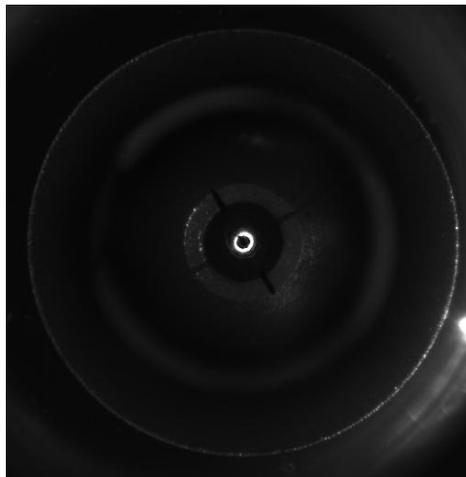


Figure 12: Once aligned to the rear aperture of the MAS, the back-reflection from the laser heating beam will be a clear ring pattern at higher laser powers and an unusual diffraction/interference pattern at lower powers.

6. (Optional) Remove the camera and replace it with a photodiode.
7. (Optional) Optimise the transverse position of the objective lens by minimising the power reflected to the photodiode. This can result in better alignment than using the camera alone, but only small tweaks to alignment should be made. If alignment into the rear aperture is lost during this stage, replace the camera and return to step 5. The photodiode can be used to monitor drifts of the heating laser alignment.

Cracking the MAS

If the MAS has been exposed to ambient conditions during handling, then an oxide layer can form on the surface of the metal. If this has occurred, this layer must be broken up by initially heating the MAS at higher laser powers, until neutral fluorescence is observed from the atom beam. This procedure is referred to as 'cracking'. Once first fluorescence is observed, the running power of the MAS should be minimised. Extended running at high optical powers may damage the MAS, increasing the divergence of the output atom flux. **Please do not exceed the maximum optical power stated in the technical datasheet provided with the MAS.**