RGO/La Palma Technical Note No 29

CCD Cryostat Use

Describes the method of liquid nitrogen filling and temperature monitoring.

Paul Jorden (RGO)

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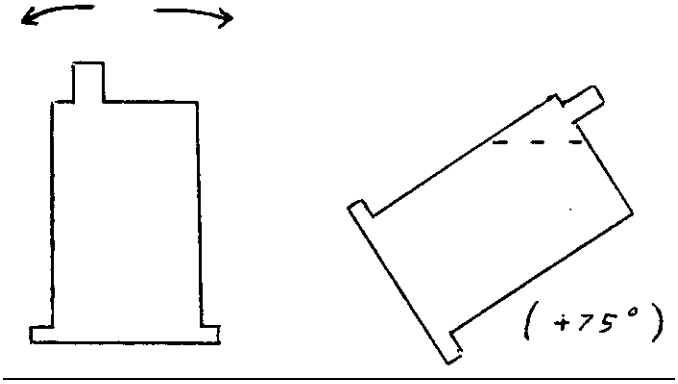
Background

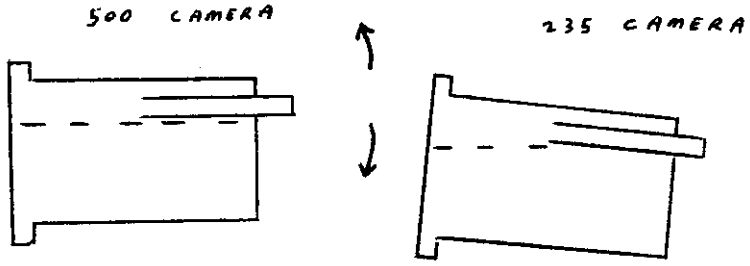
Since installation of the Cass. spectrograph and FOS CCD cameras it appears that there have been several problems associated with liquid nitrogen filling and temperature monitoring. The cryostats are used at horizontal or inverted orientations and the re-entrant fill tube has caused difficulties during filling. In particular, it seems that (inexperienced?) staff have failed to properly fill the cryostat with the result that the nitrogen runs out and the detector warms up prematurely. The detector temperature is only readily monitored via the instrument computer, and this is often unavailable for a variety of reasons.

La Palma CCD Cryostat Configurations

INT Prime
± 76^{o} Zenith Angle
No Insert tube
Fill tube uppermost at access-park (78^{o}) 1.3l max capacity (could be ~ 0.7l if then tipped to -75^{o})

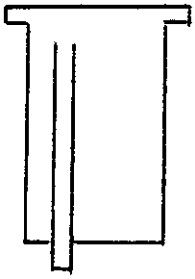


INT Cass
Offset half-length
insert tube; fill tube uppermost. Cryostat "Horizontal" on spectrograph
When filled (Tel. at Zenith), capacity l- 1.3 l
(When tipped it could reduce to ~ 0.7l)



INT FOS
Full length insert tube
Capacity at Zenith ~ 1.5l
[Should not reduce much when tipped.]
(Cryostat capacity to be increased to 3l soon)

JKT CCD
offset, full length insert tube
Cryostat used inverted, capacity 1.4 - 1.5l (similar to FOS)



Cryostat description (FOS not included)

We have attempted to use a standard Oxford-Instruments cryostat for all applications (the FOS is something of an exception). The 'normal' cryostat is used upright with a downward viewing window, as fitted on the INT Prime focus. The neck is offset from centre so that a larger-capacity is obtained when the cryostat is tipped appropriately. The maximum liquid nitrogen capacity is 1.5 litres when upright.

For fully inverted operation (JKT CCD) a full length insert-tube is added, this allows nearly the maximum capacity. For horizontal (or near-horizontal) mounting then the cryostat is arranged with its fill tube uppermost and with a half-length insert to give at least 50% capacity when tipped above or below the horizontal.

Thermal properties

All cryostats should be filled to at least 1.2l capacity initially, and if kept at Zenith position say, giving about, 16 hours hold time. If the telescope is tipped to the least favourable inclination then nitrogen loss will occur and the hold-time can be reduced to 10 or 12 hours.

In order to minimise nitrogen boil-off and give some temperature control the detector assembly (and temperature sensor) have an intrinsic time constant. This explains the 2-3 hour cool-down period. A further effect is that if the

liquid nitrogen runs out completely then it may take an hour or so before any temperature rise is detected. The temperature rise may then be rapid.

A description of the nitrogen filling process

Initial cooling

It is assumed that the cryostat has a good vacuum and that it starts at room temperature. The pump should be fitted in the nitrogen storage dewar and left until fully pressurised (see indicator light). Then the fill pipe should be fully inserted into the cryostat and the pump switched on. The prime focus cryostat could be filled with a funnel, although a long tube inserted into the cryostat will help. If the fill tube is not fully inserted then a narrowing of the neck tends to blow back liquid rather readily.

Initially there will be strong boil off with perhaps some liquid blowing out as splashes. As the fill-pipe freezes and the cryostat cools liquid should be seen flowing along the pipe. After a few minutes it is quite common for a brief increased boil-off plume and a "whoosh" for 10 seconds or so; filling must be continued for 5-10 minutes typically (This may be 10-20 minutes for FOS). The cryostat is full when there is a steady stream of liquid overflowing - the strength of this is best recognised by experience. Do not move the plastic pipe until it has thawed out.

After this initial cool-down, the boil off will be quite strong and will stabilise over several hours; the detector takes 2-3 hours to cool down. During subsequent operation it is usual for ice to form on the neck; if this ice "collar" is seen to melt this could indicate nitrogen has run out. It is possible to detect the normal boil off (to ensure nitrogen is present) by momentarily blocking the exhaust port with a finger and on release one should see a brief puff of condensation or feel gas.

Topping up

To top-up the cryostat, the pump must be pressurised as before; it does no harm to blow some nitrogen through the tube before it is inserted in order to cool it down somewhat - but it will soon freeze. When the tube is inserted and nitrogen pumped into the dewar it is usual for liquid to be blown out initially until the cold liquid is flowing in regularly. Again, there should be a period of several minutes when liquid flows in, with only a gas plume being seen. Finally a steady overflow of liquid indicates the cryostat is full.

Recommendations

Routine operation

When initially filling the cryostat, or topping it up later, there is no substitute for previous experience. The filling is done by using the electric pump normally and one needs to be confident that the cryostat is full - as indicated by the overflow of nitrogen. It is very necessary to have a good routine for checking the cryostat nitrogen and re-filling; this should be done by a resident technician.
The temperature monitor is not intended to warn of nitrogen loss, since it can only indicate when it is really too late!

The cryostat should be checked at least every eight hours and topped-up on a regular schedule at least every 12 hours. If the telescope is tipped and there is significant nitrogen loss, this should be recorded and the cryostat checked rather earlier. I think the support astronomer should have the responsibility for seeing that the resident technician checks and fills the cryostat as required.

Suggestions for training

Allow the technician to fill a warm cryostat once or twice to gain experience (off the telescope?). Similarly he should refill it once or twice, when mounted on the telescope, but not in use. Get used to the expected boil-off indication. Know how to recognise when the cryostat is full. Remember approximately how long it takes to fill. Allow the nitrogen to run out in order to find out how long it lasts (when no usage is planned of course!) Try tipping the telescope severely and again check how long the nitrogen lasts.

Further notes

If the cryostat does warm up, it is possible to refill it and use it although the vacuum will ultimately degrade, and repumping will be necessary in time. There is no practical way of monitoring nitrogen level in the cryostats and so routine personal checking is necessary. The temperature monitor is not a sufficient indicator and could only show the situation afterwards.