Facility

PROGRESS REPORT FOR THE PERIOD

CALENDAR YEAR 1976

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FAR-ULTRAVIOLET ROCKET ASTRONOMY PROGRAM

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INTRODUCTION

This progress report covers the launch of sounding rocket 26.056 DG on 29 October 1976, and quick-look results from that mission. It also reports further work on data obtained by 13.118 DG, launched 5 December 1975.

ROCKET EXPERIMENT 26.056 DG

This experiment carried a new, large electrographic Schmidt camera, described in the previous progress report. It had a 15 cm effective aperture, f/2.0 focal ratio, and a wavelength range of 1230-2000 A (defined by the CaF_2 corrector plate and the CsI photocathode). The camera was used in direct imaging mode, looking out the nose of the rocket, to observe two targets: (1) the Andromeda Galaxy (M-31), longest exposure 100 seconds, and (2) the North America Nebula region in Cygnus (longest exposure 50 seconds).

Although the camera achieved high resolution and good image uniformity in laboratory testing with a solenoid focusing coil (see previous progress report), we encountered substantial difficulty in getting equivalent performance using a permanent bar-magnet array (analogous to those used with previous cameras) to provide the focus field, (as necessary for flight applications of the camera). In particular significant distortion and image shift (relative to the optical axis) was noted; presumably this is due to nonuniformities in the magnetic field produced by the bar magnet array, and is very difficult to correct once the array is fabricated. Therefore, the image quality achieved in this flight is not indicative of that which would be achievable with a properly designed and constructed magnet.

Under a separate grant (NASA GSFC DPR S-55917A, Astronomy Spacelab Payloads Study), we have subcontracted to Raytheon Corp. for a design study (now completed) of a self-shielded permanent magnet assembly which will provide much better field uniformity than the bar magnet array. However, this magnet would be too large (19 inch diameter, 160-200 lbs) for sounding rocket flights (unless on an Aerobee 350 or Aries vehicle).

Although the camera was kept in high vacuum for more than 48 hours before launch, a moderately severe corona discharge was encountered following high voltage turnon at 100 seconds after launch. This significantly degraded the observations of the first target (M-31), but was nearly gone during the observations of the second target (Cygnus). This behavior seems to indicate that a source of trapped gas was opened up by the force of the launch, and took a significant part of the flight time to eliminate.

Fig. 1 is a comparison of the 100-second exposure on the Andromeda Galaxy with a ground-based visible-light photograph. The northern quarter of the galaxy image is obscured by the corona discharge, but this produces only minor interference to the rest of the image. Although the corona fogging was less severe on a 30-second exposure, M-31 is just barely detectable in that exposure. Therefore, from comparison of the present camera's sensitivity with that of the Apollo 16 Far-UV Camera (Experiment S-201) based on the Cygnus observations, we would conclude that

M-31 is much fainter in the UV vs. the visible than is the Large Magellanic Cloud, observed by the S-201 camera.

The image of M-31 reveals (see Figs. 1 and 2) that the associations of early-type stars in the spiral arms are significant sources of ultraviolet radiation, as expected. However, there is also a significant UV source, comparable in intensity to any of the others, centered on the nucleus of the galaxy. This source had previously been detected by the University of Wisconsin ultraviolet photometers on OAO-2; however, the much higher spatial resolution (20 arc sec) achieved by the present rocket observation allows us to determine the size and intensity distribution in this central source. By comparison with nearby faint star images, it is seen that the central source is definitely not point-like, but has an extent of some 2 or 3 arc minutes. Thus, it could be due to a diffuse concentration of hot stars, or to dust-scattering of radiation from a central point-like source. Microdensitometry of the M-31 imagery is presently in progress.

The image of the North American Nebula region in Cygnus (Fig. 3) reveals, in comparison with the earlier Apollo 16 imagery of part of the same field, a significantly improved resolution (20 arc sec vs. 3 arc min) and point-source sensitivity; surprisingly, however, the rocket camera proved also to be more sensitive to the diffuse nebulosity. This can be seen in particular when one considers that the rocket camera exposure is only 50 sec. vs. the 10-minute exposure from Apollo 16. The S-201 camera, with f/1.0 focal ratio, should in principle be a factor of 4 faster for diffuse sources than the present f/2.0 camera; however, this factor is accounted for by the better reflectance of the present Al + MgF_2 coated mirror (vs. rhenium on the S-201 mirror) and the use of a CsI photocathode (vs. KBr for S-201).

We estimate, on a quick-look basis, that the rocket imagery reaches stars at least 3 magnitudes fainter than reached by S-201 with 12 times longer exposure. This supports our estimates of camera sensitivity included in our proposal for its use in the Spacelab II mission. In addition to the North American Nebula, many other diffuse bright (and dark, in silhouette) nebulae are revealed, which correspond to features seen in ground-based visible-light photographs. A general diffuse background, believed to be real, is seen over the entire frame, and appears distinct from localized areas of corona-induced background.

Due to partial failure of the payload recovery system, the payload and camera were severely damaged on impact. Therefore, of the funding requested for the next two flights ($22,000 for 25.026 DG and 25,027 DG), most will be needed to refurbish the existing equipment for use in 25.026 DG. It will be necessary, therefore, for us to submit a new proposal for support of 25.027 DG (which requires a completely new payload).

PLANS FOR NEXT FLIGHT

The electrographic Schmidt camera used in 26.056 DG is planned for reflight on 25.026 DG in the fall of 1977. This time, the camera will be equipped with an objective grating, and a LiF corrector plate, to provide spectra of stars covering the 1050-2000 A wavelength range. The target stars are tentatively planned to be the identical starfield in Cygnus which was observed in the flight of 26.056 DG. Attempts will be made, in the interim, to improve the field uniformity of the bar magnet array by a trial-and-error process of trimming and testing.

FURTHER WORK ON 13.118 DG DATA

Three papers (attached) have been submitted for publication based on the analysis to date of the Orion imagery and spectra obtained by 13.118 DG 5 December 1975. C.R. O'Dell and B.S. Askins of the Marshall Space Flight Center have developed a new method for the autoradiographic enhancement of photographic images. We have been working with them in the use of this technique also for electrographic images, and factors of 10 or more improvement in image density have been demonstrated. Askins and O'Dell have activated two of our underexposed all-reflecting camera frames of the Orion Nebula region (10 sec. direct image and 5.5 sec. objective spectrogram), which has resulted in a much larger region of the Orion Nebula being detectable in the direct imagery, and considerably fainter stellar spectra being detectable in the spectrographic exposure. (In both frames, the degree of autoradiographic enhancement is limited by the film background due to the Lyman-α nightglow and to ionic background within the camera). We still find no trace of any discrete line emission from the Orion Nebula, which is consistent with the finding of Bohlin and Stecher that the spectrum of the nebula is primarily due to dust scattering of radiation from the central θ Orionis star cluster.

Prints of the autorodiographically-enhanced Orion Nebula imagery and spectra, and of a comparison of UV and visible images of the nebula, are attached (Figs. 4 and 5). Compare these to the unenhanced versions in the previous progress report.

FIGURE CAPTIONS

1. (LEFT) Far-ultraviolet (1230-2000 A) image of the Andromeda Galaxy obtained with NRL electrographic Schmidt camera in rocket flight 26.056 DG (exposure time 100 sec.), compared to (RIGHT) Ground-based visible light exposure (Palomar 48" Schmidt) to same scale. Arrows in UV picture point out sources associated with the nucleus (upper) and with an association also seen in the visible photograph (lower). The bright streaks and bright area in the upper part of the UV picture are due to coronal discharge in the camera.

2. Outline of observed regions of significant UV emission in M-31, and identified stars (by SAO Catalog numbers or name).

3. Far UV image of the North America Nebula region of Cygnus (50 sec. exposure) obtained in flight 26.056 DG. Field of view is 11 degrees. Streaks in upper part of picture are due to corona in the camera. Distortion evident around the edges of the image is due to irregular field of the permanent focusing magnet.

4. Autoradiographically enhanced far-UV image of the Orion Nebula (left) and objective spectrogram (right) from rocket flight 13.118 DG. Wavelength range in spectra is roughly 1000 A (left) to 1600 A (right), strongest feature is Lyman-alpha (1216 A).

5. Comparison of autoradiographically enhanced direct image of the Orion Nebula (left) with a ground-based visible light photo (right). (Lick Observatory photograph)

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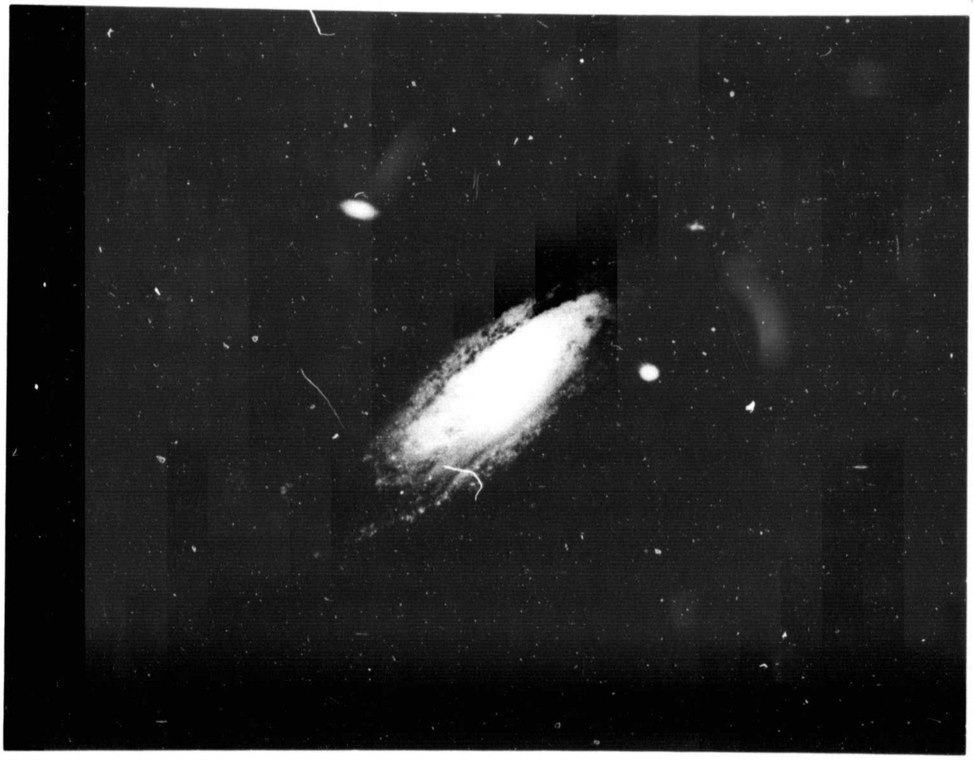

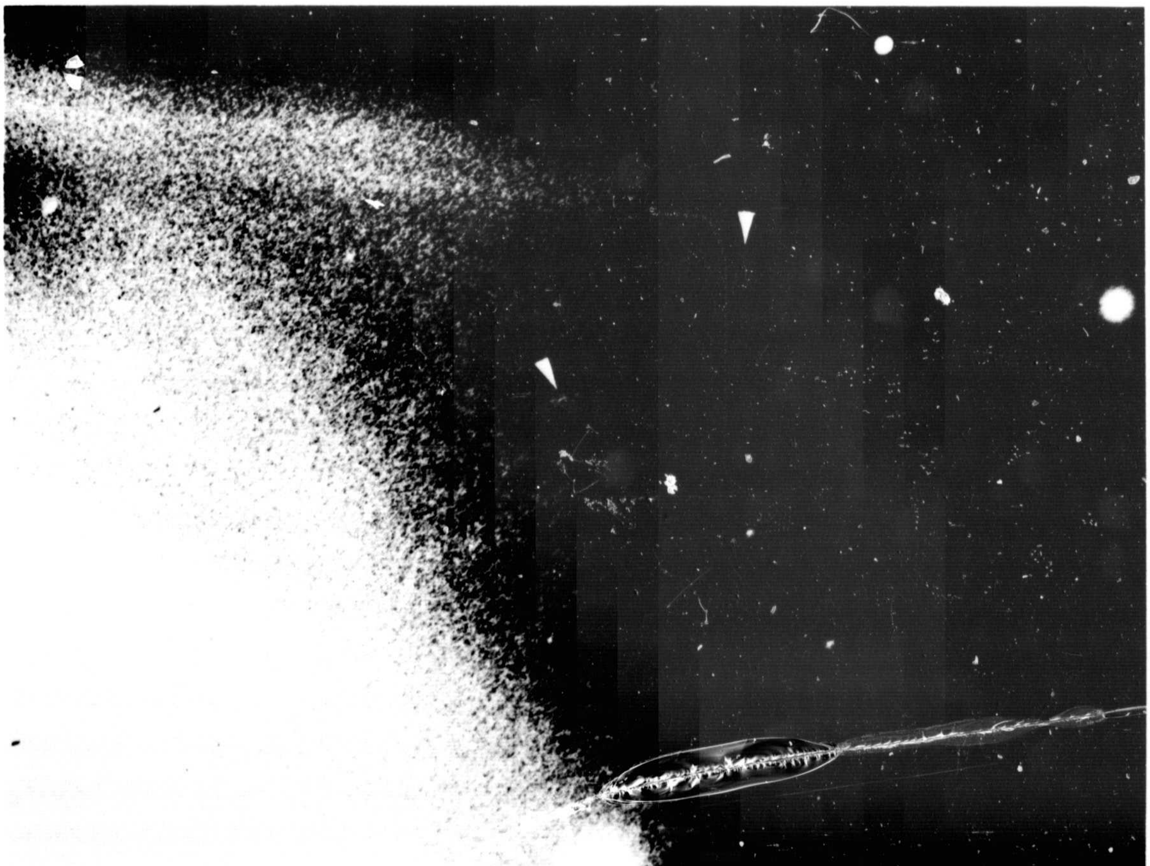

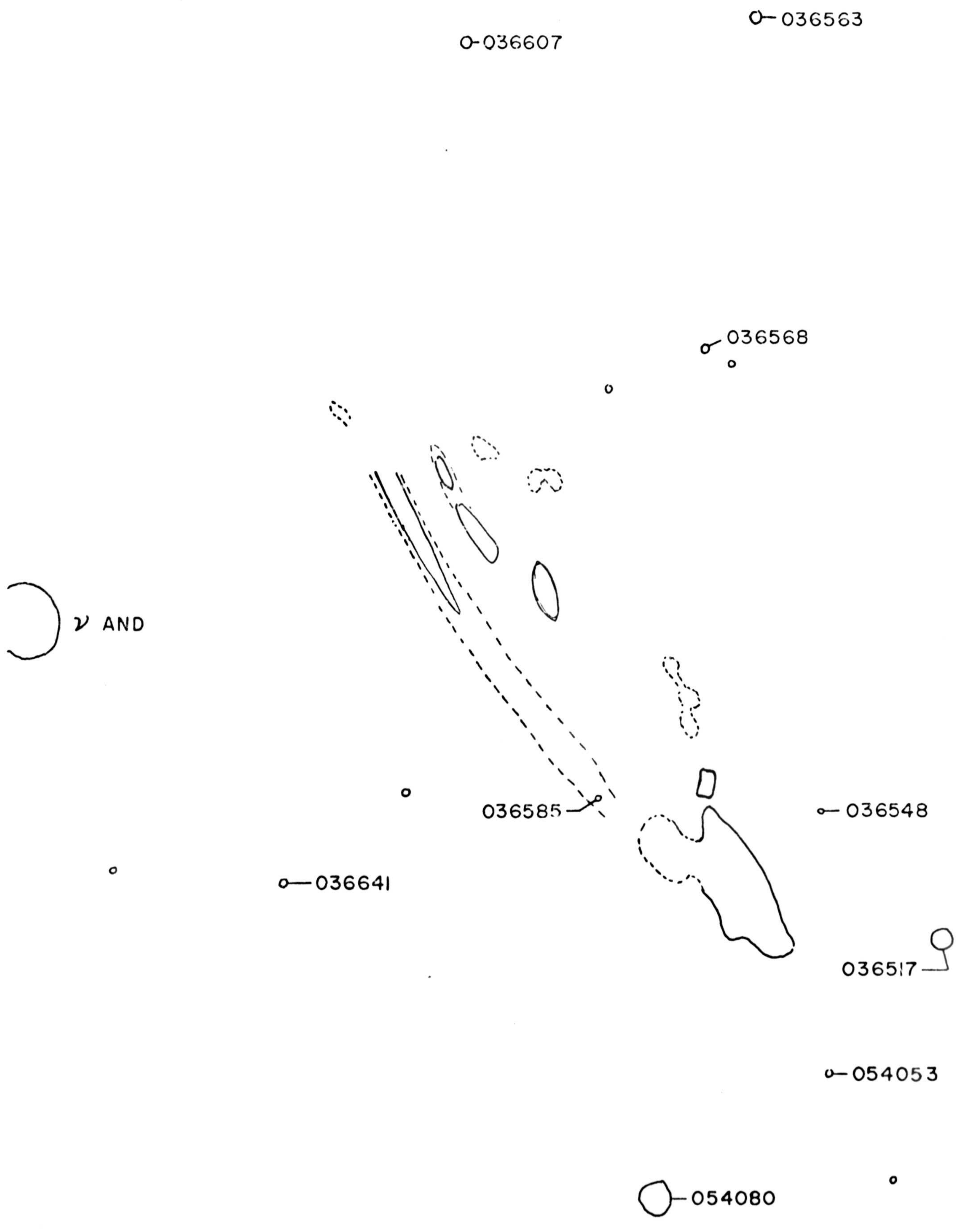

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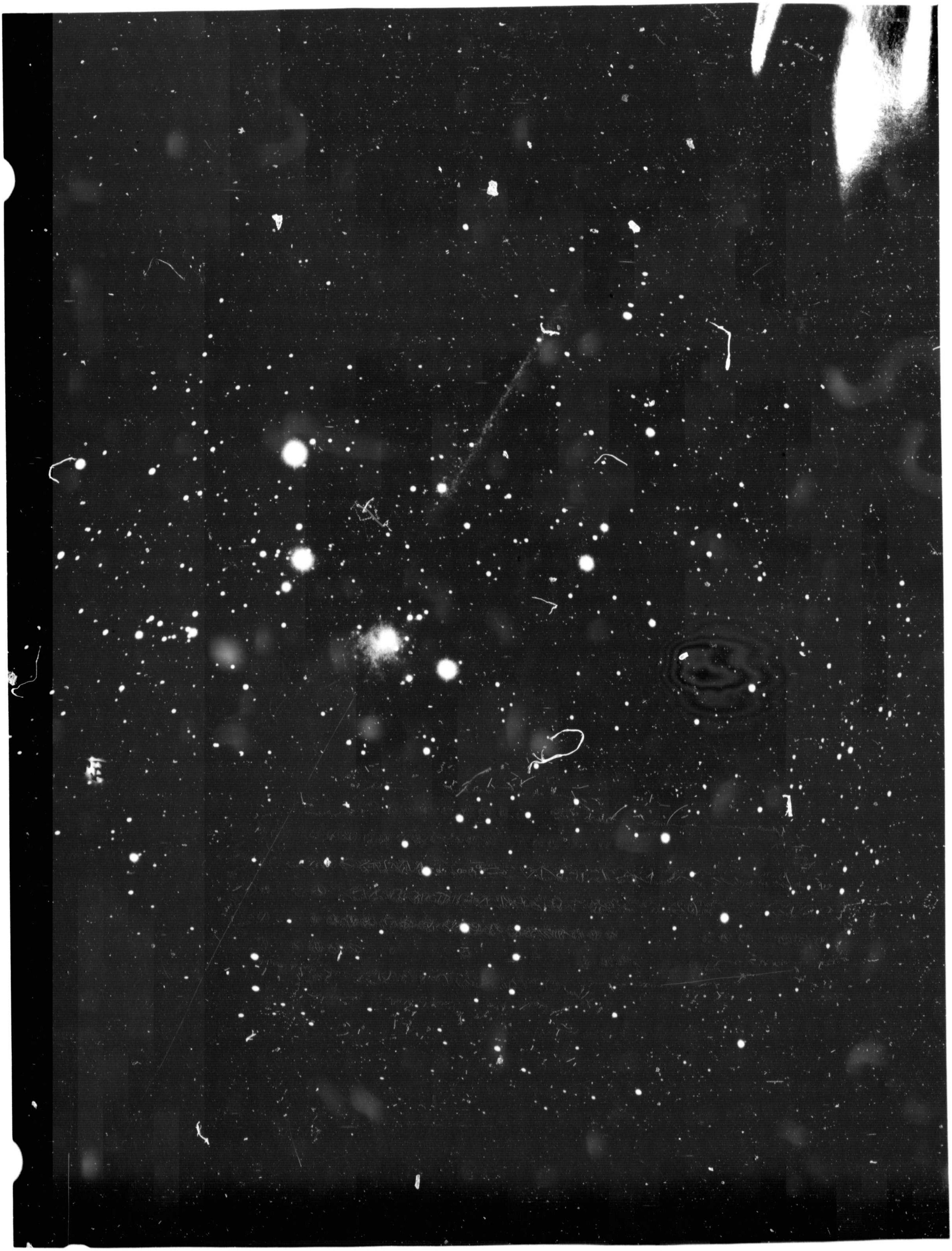

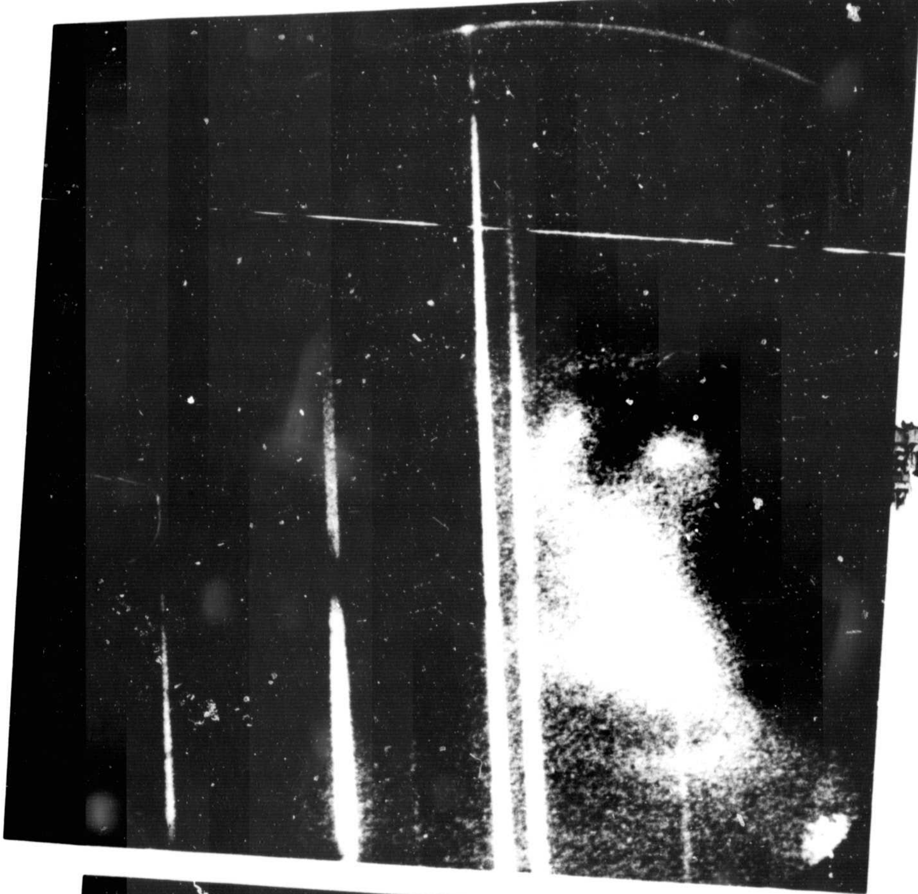

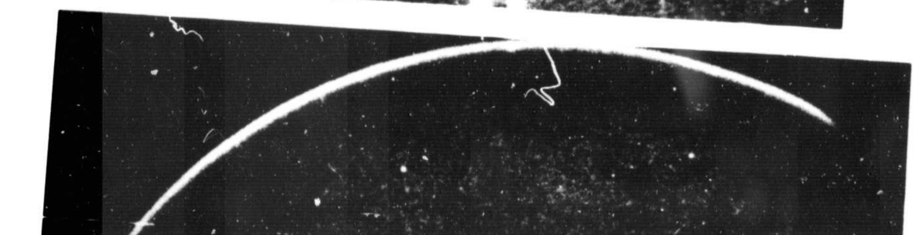

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