PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Recent Results in Ultraviolet Astronomy Obtained by a Wide Field Rocket Camera and the French S 183 Skylab Experiment

G. Courtes, M. Laget, J. P. Sivan, M. Viton, A. Vuillemin and H. Atkins

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Recent results in ultraviolet astronomy obtained by a wide field rocket camera and the French S 183 Skylab experiment

By G. Courtès, M. Laget, J. P. Sivan, M. Viton, A. Vuillemin
Laboratoire d'Astronomie Spatiale du C.N.R.S., Marseille, France

and H. Atkins
Marshall Space Flight Center, Hunstville, Alabama, U.S.A.

[Plates 13–16]

A large survey of the sky has been undertaken in the near u.v. in two different steps by the Laboratoire d'Astronomie Spatiale du Centre National de la Recherche Scientifique:

1. A wide field camera 120 × 80° survey programme on rockets began in 1967 and was continued by the launch of the Janus camera in 1972.

2. A medium field (6 × 8°) programme due to the S 183 French experiment on Skylab.

The map shows the distribution of the S 183 fields on the celestial sphere, superposed with the two wide fields of the Janus camera (figure 1).

A complementary work in visible light (H α) using similar wide field (60°) optics and very selective interference filters has been made during the same period in order to obtain an idea of the penetration in interstellar space of radiation below 912 Å owing to ionization of the interstellar hydrogen considered as evidence of this radiation. The full set of these experiments in u.v. and H α gives a good synthetic figure of the extreme population I extension in the Milky Way.

1. Very wide field cameras

(*a*) *Rocket experiment*

A new wide field u.v. camera 'Janus' with two optical channels (2650 and 3350 Å) observing simultaneously has been used on the Eridan rocket (Sivan & Viton 1970; Courtés (1971).

The altitude of the exposures was 115–235 km. Almost 1500 stars have been detected and their fluxes will be compared with an absolute calibration source using the Cerenkov effect and recorded aboard during the flight.

The first measurements show a probable accuracy of the flux of the order of $\Delta\phi = \pm 0.1$ magnitude. The limiting magnitude is $m_{\mathrm{v,lim}}$ (2650 Å) = 9 for O stars, $m_{\mathrm{v,lim}}$ (3350 Å) = 10 for O stars, and 7.5 for A stars, with an exposure time of 147 s.

The concentration of early type stars can be seen on the plates (figures 2 and 3), the Milky Way extending from Orion to Carina.

One notes, in spite of the very short rocket exposure time, the detection of Barnard's Loop in Orion. This is likely to be due to the [O II] emission line† (0.09 transmitted by the coating) and may be the dust scattering continuum.

† A 3727 Å [O II] survey made from the ground needs a much longer exposure time to detect Barnard's Loop; hence the interpretation of this faint feature on Janus camera is not certain. Recent investigations seem to show that this detection of Barnard's Loop is more likely due to the combination of the Balmer continuum and the absorption and scattering by the interstellar dust.

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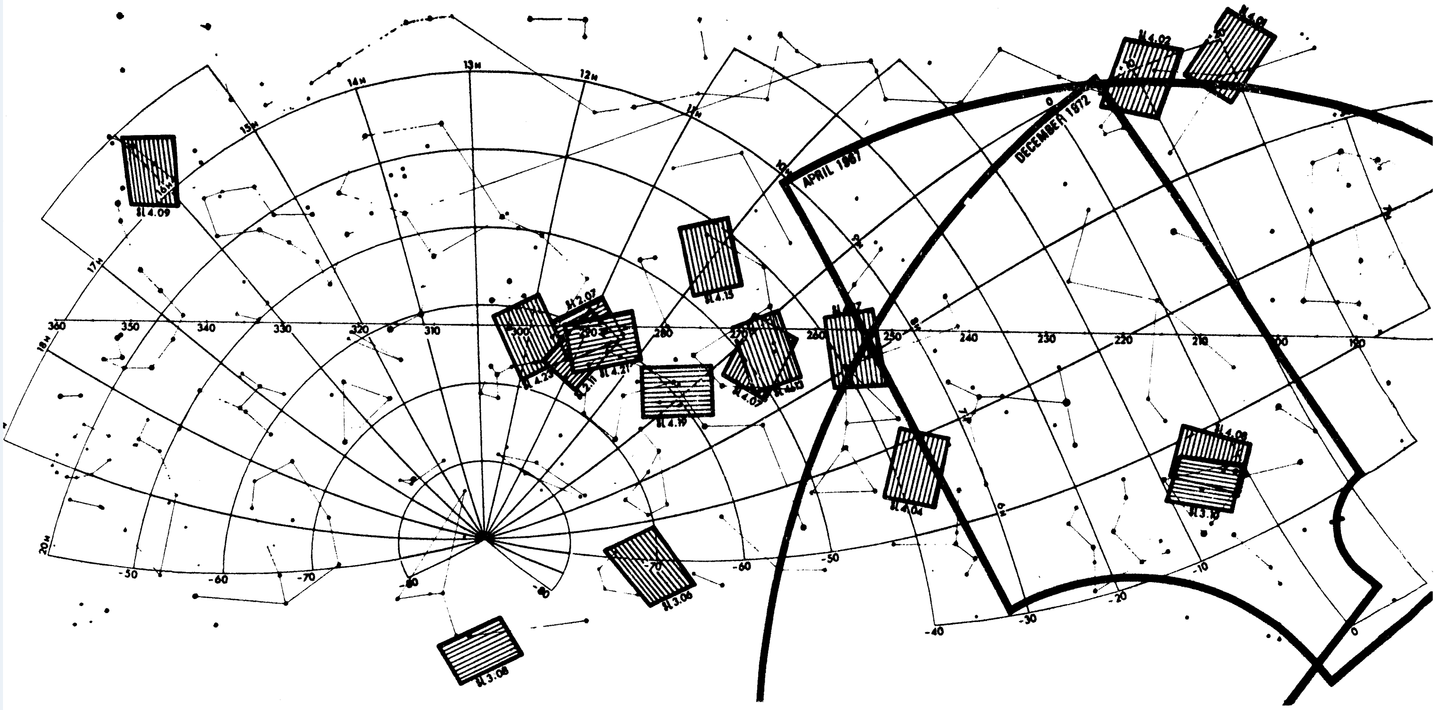


FIGURE 1. Map summarizing the u.v. surveys of the L.A.S. (Laboratoire d'Astronomie Spatiale du C.N.R.S.).

The main characteristics of the Janus camera are: mean aperture camera 4.7 mm; focal ratio $F/1.35$. The very small focal length was necessary to minimize the size of the image track on the emulsion, the instrumental stellar image being smaller than 15′ (i.e. 9′) in the whole field. The stabilization of the rocket was obtained by an inertial platform 'Pagode' of the 'Cassioppee' rocket stabilization system of the Centre National d'Etudes Spatiales.

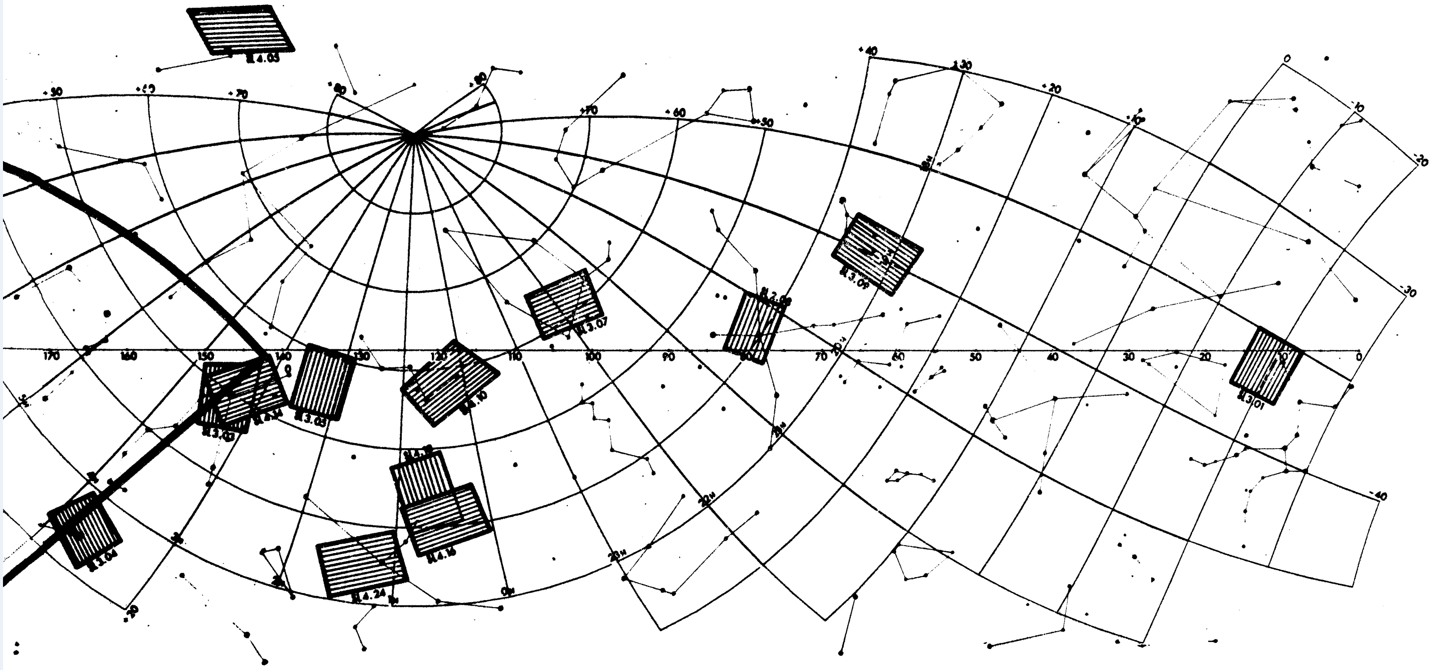
The quality of the focusing can be judged from the enlargement, given in figure 4, in the best part of the field, for instance around Orion. Fortunately the same field has been observed by Weber, Henzy & Carruthers (1971) at 1500 Å with an electronographic camera.

When comparing these results, it is interesting to note the good sensitivity of the 103aO Kodak plate at 2650 and 3350 Å, since the flux collected by the Janus camera was almost 100 times fainter for an exposure time only five times longer.

(*b*) *Related ground based wide field observations* (Courtès & Sivan 1972)

The mosaic studies of the Milky Way are inconvenient for studies and make difficult photometric comparison, for example, on both sides of the Milky Way. Profile of brightness and detection of new faint extended features need a field of at least 60°.

A new camera of 60° field and focal ratio $F/0.7$ has been specially designed (Sivan 1974*a*) and can use, as an additional improvement, very narrow interference filters. A description of this instrumentation and results has already been published by Sivan (1974*b*). In this review we recall only the H α emission survey (see figure 5) which detected 12 new large H II regions and a general diffuse galactic H α emission similar to the one discovered in the disk of M 33 by Carranza *et al.* (1968) and several other galaxies by Monnet (1971). The very irregular distribution of the interstellar hydrogen clouds described during this symposium by Morton, and the low value of hydrogen density, allow us to interpret the excitation of Balmer lines,



sometimes 500 pc away from exciting stars, as an effect of u.v. radiation below 912 Å transmitted by chance, between the H clouds. The H α general survey will give a good indirect way for obtaining a first evaluation of the far u.v. galactic radiation. Accurate radial velocities of H α by Georgelin & Georgelin (1973) will be compared with the Ly α radial velocities obtained in absorption on the Copernicus spectra.

2. The 7 × 9° field of view spectrophotometric galactic survey

The S 183 experiment was developed by Courtès, Laget and Vuillemin with the collaboration of Atkins. A summary description of the optical concept has been given by Courtès (1971). The apparatus was installed for operation on the anti-solar airlock by the astronauts.

Three passbands were available centred at 1878 and 2970 Å, each with a half-maximum bandwidth of 636 Å, and at 2558 Å with a half-maximum bandwidth of 356 Å. The first two bands were recorded with the principal apparatus; the last band was obtained by a separate camera equipped with a Schmidt Cassegrain telescope ($F/3, f = 74$ mm), the band being defined by the mirror coatings. In both cases the limiting magnitude recorded was in good agreement with the predictions:

passband	spectral type	$m_{\mathrm{v,\,lim}}$
2970 and 1878 Å	A O	7
2558 Å	O	12

The best results were obtained with the Schmidt Cassegrain telescope. Some 4000 stars were recorded, chiefly in the southern part of the Milky Way in the regions of Vela, Puppis, Carina and Centaurus. Regions located in the constellations of Orion, Taurus, Perseus and Cygnus were also observed.

One interesting picture is shown in figure 6, which concerns the Large Magellanic Cloud. It is noticeable that only population I stars are detected at 2558 Å, while the late type stars of the central part have completely disappeared. A comparison with the results obtained by Carruthers at 1500 Å with a Moon-based electronographic camera during Apollo **16** confirms the population I distribution.

Another example of these data is shown in figure 7 for a field in Carina.

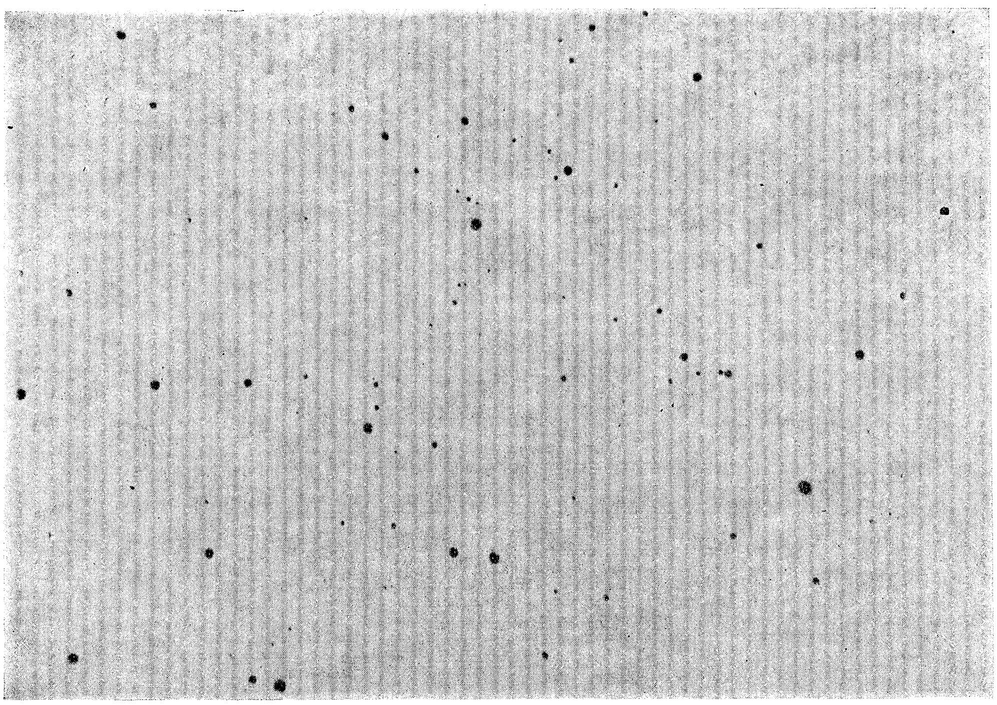


FIGURE 7. Field in Carina: α = 9 h 10 min; $\delta = -60°$; λ = 2500 Å; exposure time = 5 min. Skylab S 183.

With this brief description of these preliminary results, we would like to thank the National Aeronautics and Space Administration, the Centre National d'Etudes Spatiales, the European Southern Observatory and the Centre National de la Recherche Scientifique for their support during preparation and operation of the above-mentioned experiments.

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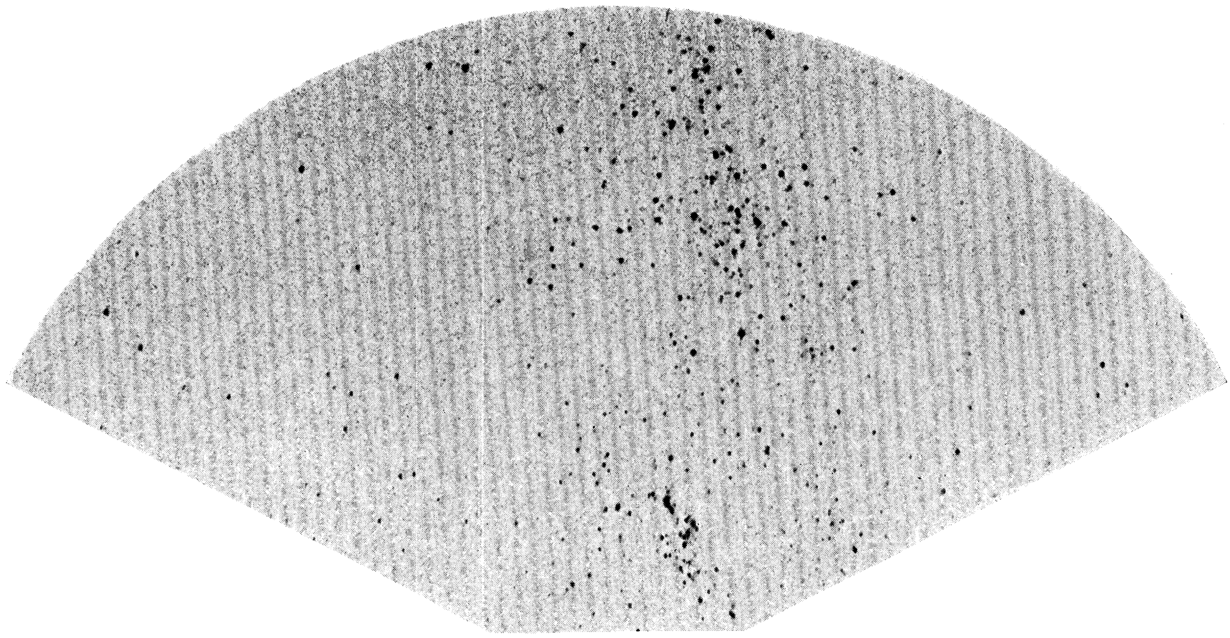

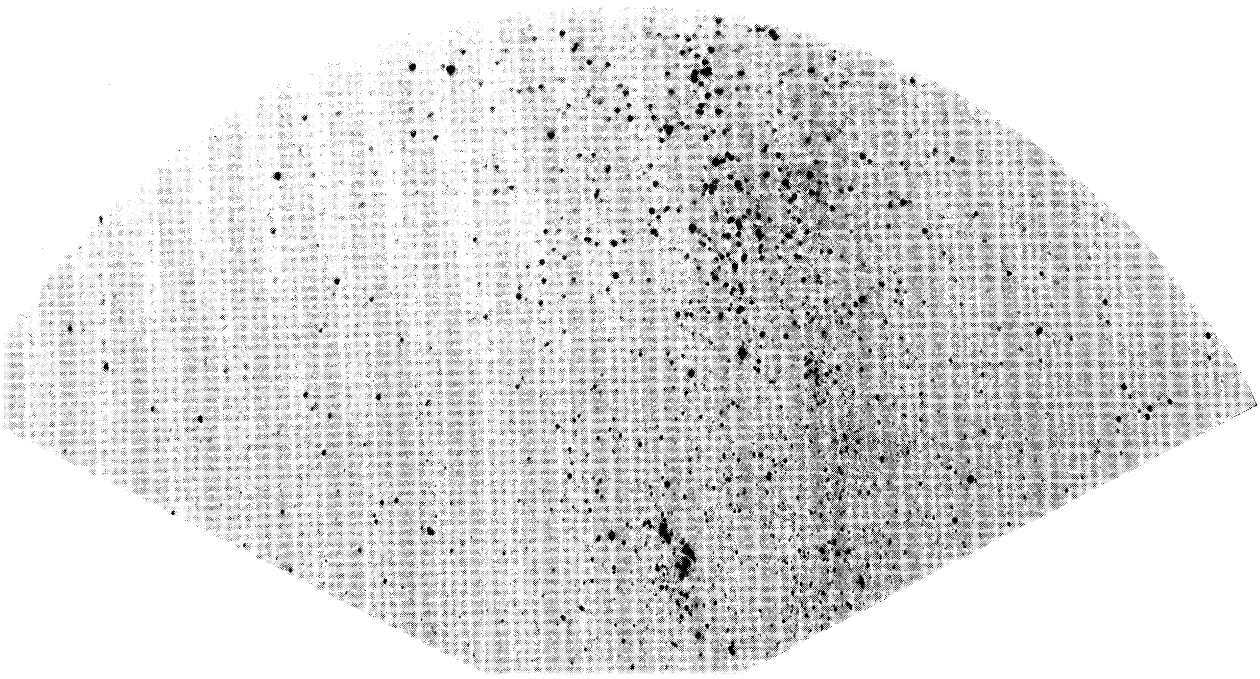

FIGURE 2. Wide field in the southern Milky Way. Janus camera bandwidth peaked at 2650 Å. One recognizes the Orion constellation upside down at the bottom.

FIGURE 3. As figure 2, but with bandwidth peaked at 3350 Å.

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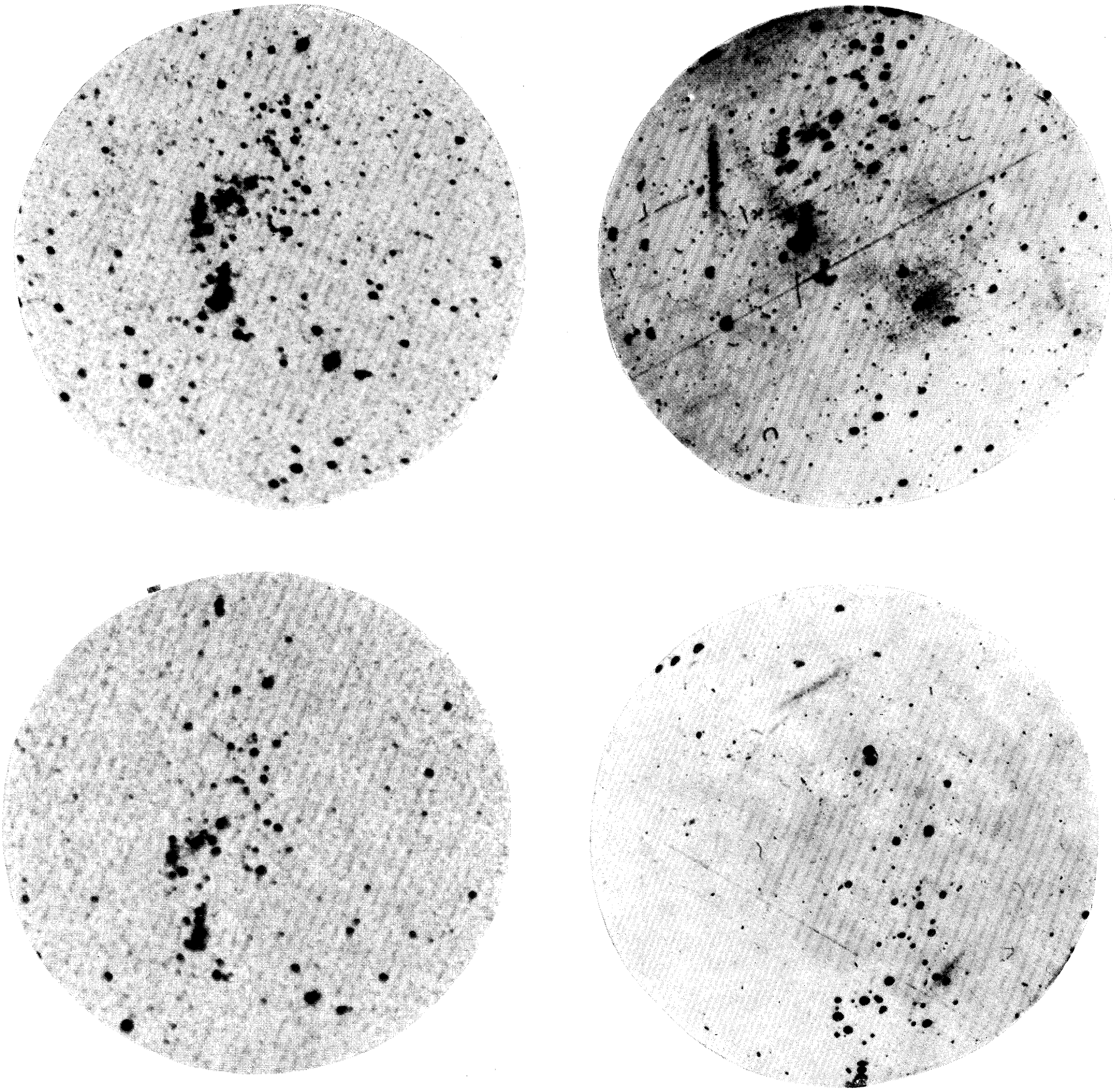

FIGURE 4. Enlargement of the Orion cluster from the Janus camera, $\lambda = 3350$ and 2650 Å on Kodak 103aO plates (left); and that obtained at 1500 Å by the N.R.L. electronographic camera (right). Exposure times: Janus, 147 s; N.R.L., 28 s. Aperture: Janus, 5 mm; N.R.L., 150 mm.

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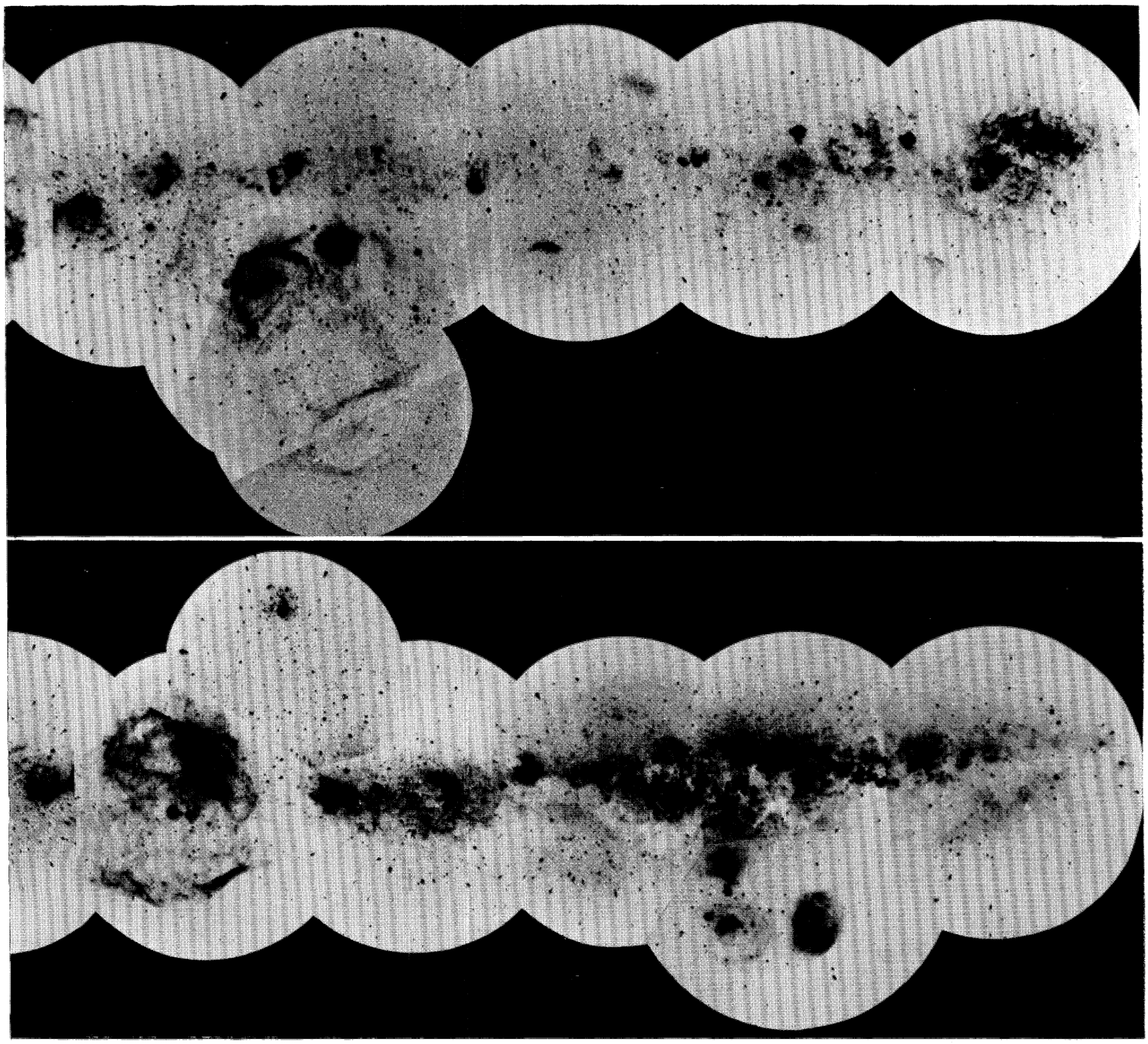

FIGURE 5. General wide field H α survey related with the far u.v. radiation of the Milky Way.

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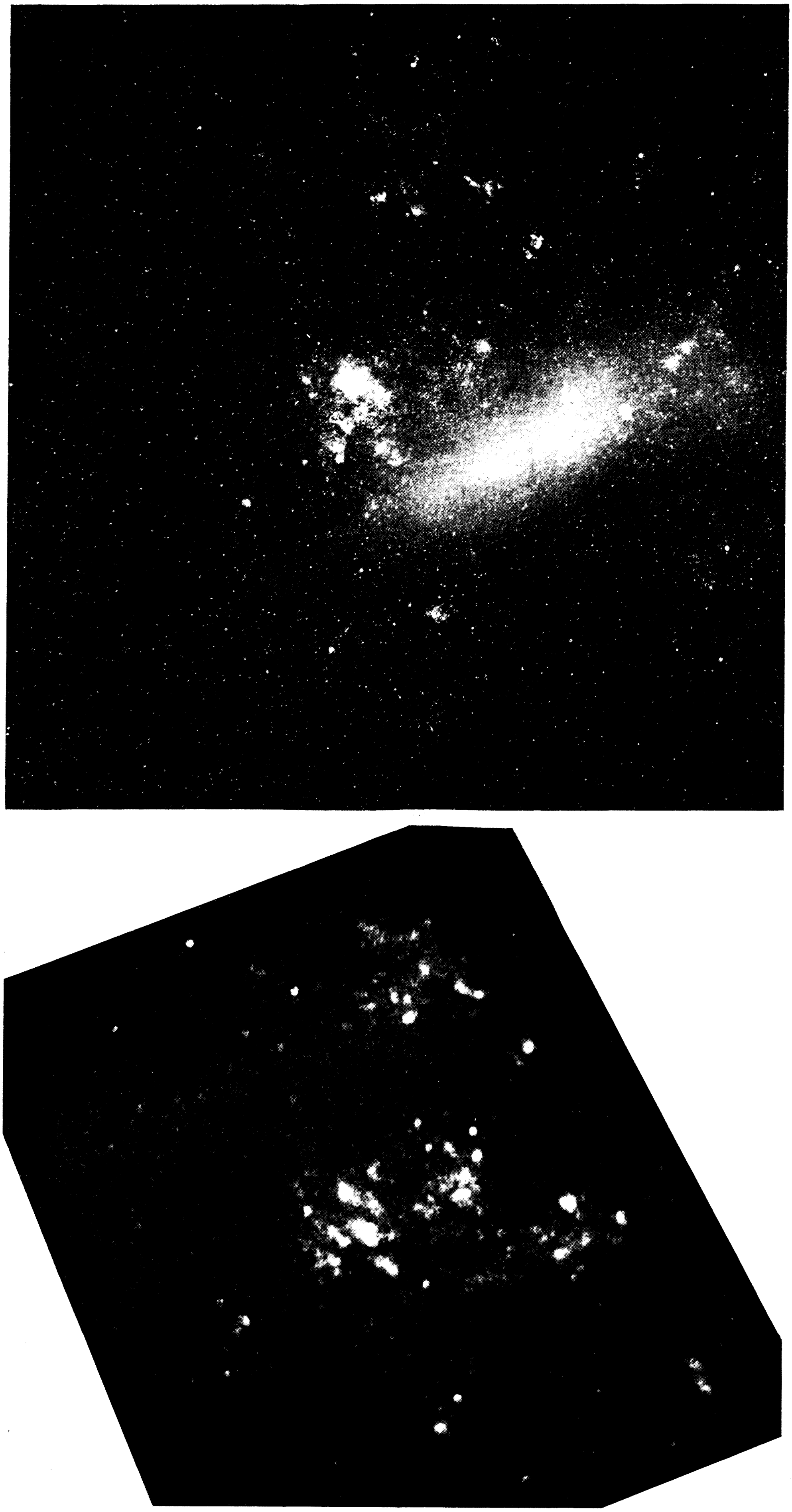
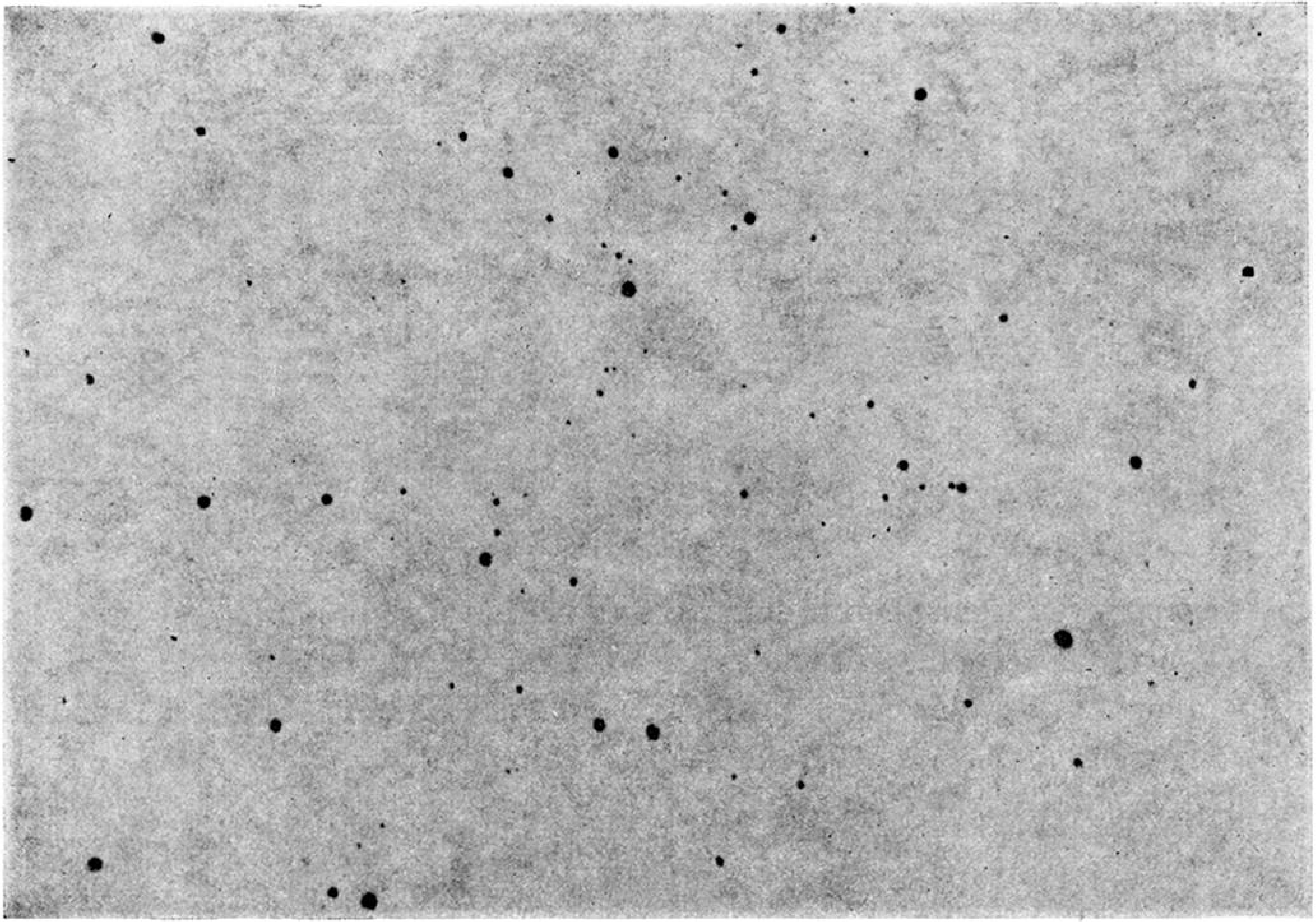


FIGURE 6. Large Magellanic Cloud. λ = 2500 Å, exposure time 21 min Skylab, S 183 (left); λ = 4000 Å, general view of the L.M.C. (right).



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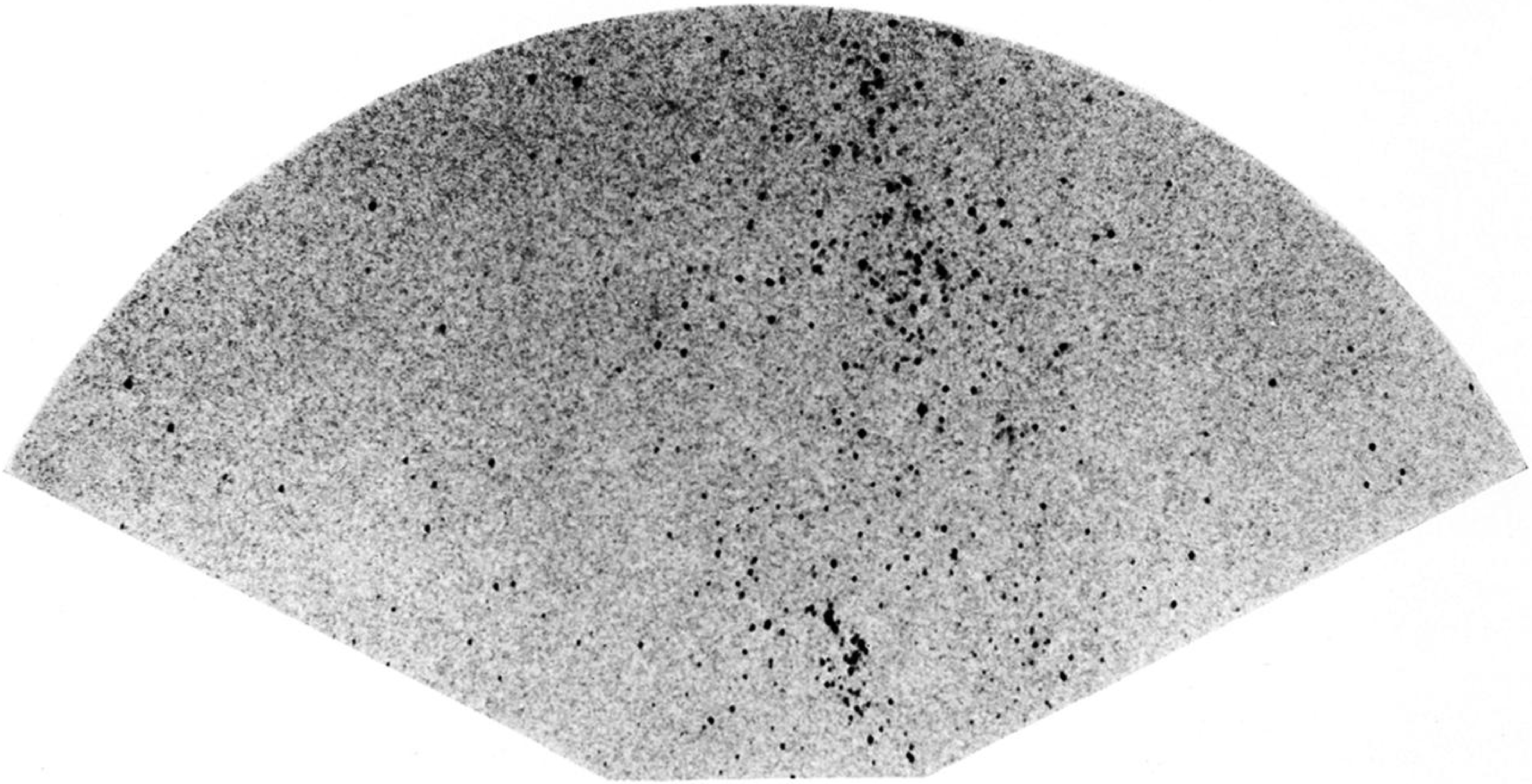

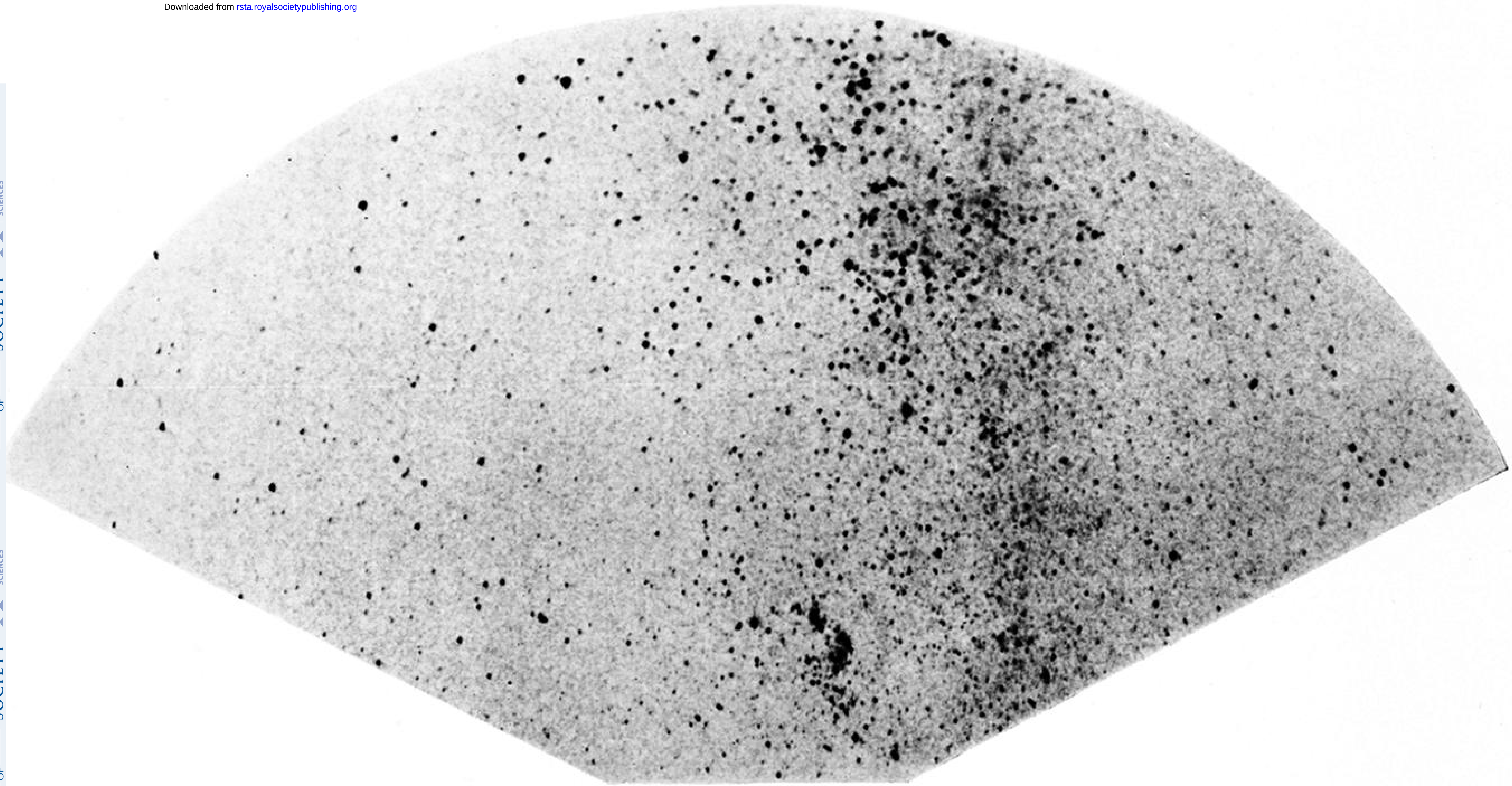

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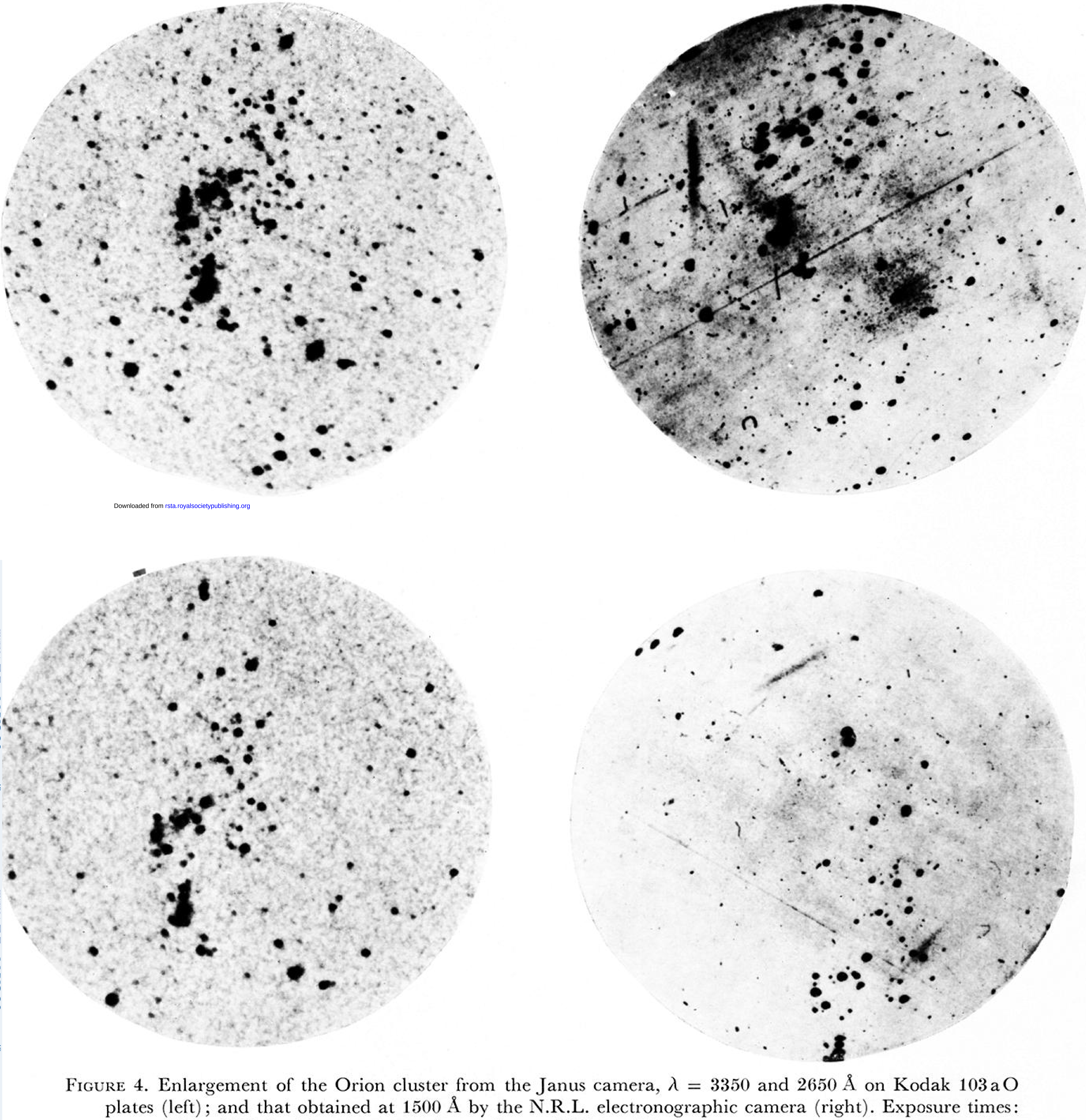

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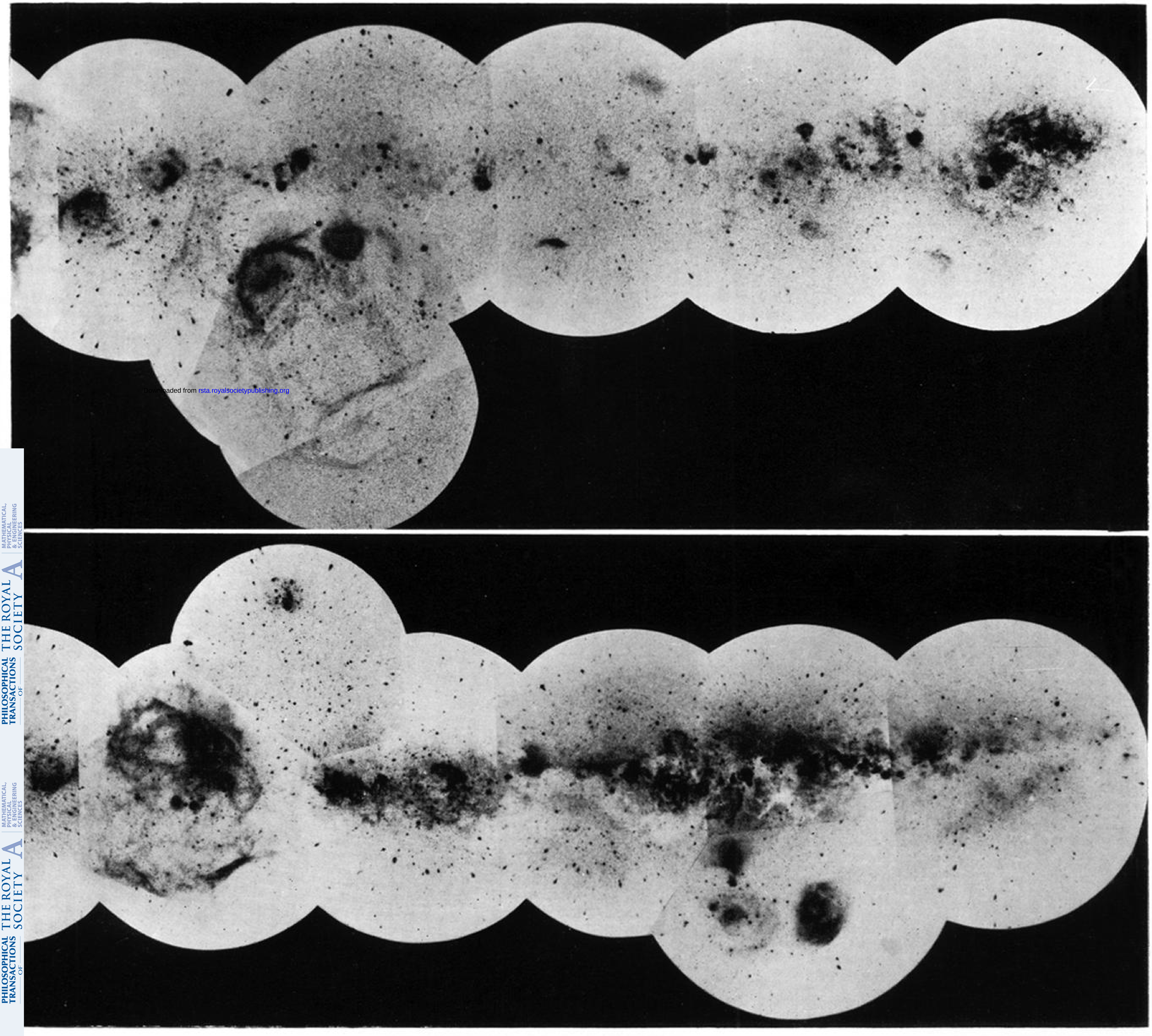

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