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CARNEGIE INSTITUTION OF WASHINGTON
MOUNT WILSON OBSERVATORY
PASADENA, CALIFORNIA

April 4, 1923.

V.M. Slipher,
Director Lowell Observatory,
Flagstaff, Arizona.

Dear Mr. Slipher:-

I am most apologetic over this long delay in returning the report on nebulae. It has gone with me up the mountain and I have read and re-read it many times. As a report to the committee it is most excellent and I heartily endorse it. The statement of policy and the discussion of survey and cataloguing are especially sound. It is surely unwise to precipitate a comprehensive program of cataloguing until some classification of nongalactic nebulae has been devised which is significant and generally acceptable. This matter is urgent and seems worth a circular letter inviting expressions of opinions and general discussion so that by the next meeting ideas may be crystallized into definite schemes. Any new catalogues should aim at uniformity, completeness within certain limits and as much physical data as possible. They should take the form of source books for statistical studies.

The fundamental division of nebulae into galactic and non-galactic and the subdivision of the former into planetar^{is} and diffuse is obvious, significant and, I believe unobjectionable save in the matter of nomenclature, a point by the way for the committee to consider. The objects are relatively few and should be catalogued separately. One can vision a complete volumn on galactic nebulae in three parts, planetar^{is}, diffuse nebulae and dark nebulosities, although the separation of the last two is open to question. Such a work could be undertaken at any time now. It would close an epoch and serve as

an advance station from which future expeditions could set forth. The work would be very largely a mere complication of data and could be handled by a small institution sanctioned by the committee, aided by grants recommended by the committee and furnished with material by the various observatories. This would clear the field for the thousands of nongalactic objects which could then be treated as a homogeneous group amenable to statistical studies.

One could continue commenting on the excellent discussions of each subhead in the report, in particular those on spectroscopic investigations and the photographic precautions in Blink comparator work.

The question over which I hesitated and ~~the~~ truth which delayed the reply, did not concern the report as a report to the International Committee, but as a presentation of the subject to the general reader, for whom of course it was not primarily intended. I feel that for him the matter might be thrown into a somewhat different form with the fundamental problems of the subject emphasized until they stand forth in bold relief against the details on which they rest. We are of course striving to determine the relation of nebulae to the universe and in order to make any headway we must know their distribution and physical nature. The investigations on parallax, motions, form, luminosity and dynamics are really subordinate to these ends. In presenting the subject to the general reader it seems worth suggesting that the significance of the lines of research discussed might be emphasized, along with the class of data, the lack of which we feel the most keenly in striving to form a working picture of the nebulae. To the initiated, reading the report against a considerable background of work and contemplation the significance and bearing of the various items fall naturally into place.

I am loth to make a comment so vague as this and have mulled over the matter at considerable length. However the report itself is excellent. My only

suggestion is that it be published as a report and not as an estimate of the situation for the general reader.

My own work, about which you have been good enough to inquire, is progressing rather slowly. I have been trying to construct a classification of nongalactic nebulae analogous to Jean's evolution sequence, but from purely observational material. The basis is a distinction between amorphous nebulosity and the granular beaded arms of spirals. As a ^{first} just approximation the following sequence suggests itself.

Amorphous	A ₀	such as	M87	or N.G.C. 3379
	A ₁		M32	
	A ₂		M59	
	A ₃		N.G.C. 3115	
Spirals	S ₀		"	4594
	S ₁		M81	
	S ₂		N.G.C. 2841	
	S ₃		M 101	

In addition are, the occasional \emptyset shaped spirals (M95) S shaped spirals, and irregular nebulae such as M82, NGC 4214 etc.

This disregards the matter of inclination of planes to the line of sight and hence the A₀, A₁ and A₂ are not individually distinguished from titled A₃. Also the types S₀ and S₁ seem to be significantly rare. These are both very serious objections.

I am applying this scheme to the nongalactic nebulae in Holetschek's list with the following results for 235 objects.

Amorphous	59	Nebulae	mean magnitude	10.28
Spirals	169			10.19 (10.22 without M31)
Irregular	7			10.20

9 of the spirals are \emptyset shaped, 5 spirals and 3 Amorphous nebulae are peculiar and cannot be definitely assigned to subdivisions.

The agreement in mean total magnitudes suggest that the quantities of material in the types are of the same order and hence it is quite possible to

conceive of them as representing different stages of an evolutionary sequence. The average surface brightness too shows a steady decrease from A0 to S3 and is a strong argument in favor of the sequence.

The situation is still complicated and considerable work will be necessary to either establish or overthrow the scheme. Possibly some modification more or less drastic can be devised to help it out. Any criticisms or suggestions that you or Lampland can offer will be gratefully welcomed. The problem is primarily one for cooperation and combination of material from all possible sources.

Then from graded series of exposures I am building up density curves for amorphous nebulosity, the measures being made on a Kock self recording microphotometer. There is a linear relation between log diameter and log exposure time for a given nebulae. The Density (or Luminosity) curves can be closely represented to within a couple of seconds of arc of the nuclei by the formula.

$$\text{Density} = \frac{\text{Constant}}{(r + e)^2}$$

Where r is distance from nucleus and e is a very small quantity varying with the form and type of the nebula. For round globular and for the short diameters of elongated amorphous nebulae, e is almost negligible and the formula approximates an inverse square law. This of course refers to the projected image on the photographic plate, and one encounters considerable difficulty in throwing it back into the three dimensional objects in the sky. I have accumulated data on some 30 nebulae, but have not commenced a thorough discussion as yet.

We are trying to get a long exposure of NGC 4736 for spectroscopic rotation to combine with Wan Maanen's recent measures, but the spring weather is very bad. I have been able to get but one exposure on M⁹⁹ (for Lampland) and that under poor conditions.

Sincerely,

Edwin Hubble

Mt. Wilson Observatory