0·021, but this is only a rough approximation. The co-ordinates of the Observatory are—

28·6s. E.
52° 12′ 10″ N.

A. C. CROMMELIN.

Trinity College, Cambridge, August 10.

Macclesfield Observations.

MANY years ago, in studying Rigaud's "Bradley," I was impressed by several references to extensive series of observations with transit and quadrant made at the observatory of Shirbourn Castle, some of which Bradley evidently thought worthy of comparison with his own inaccuracy. It has often occurred to me that these observations, if the records still exist, may well be worthy of as thorough a reduction as has been given to those of other early astronomers. Perhaps some of your readers can tell us something about these records of 1739-89. CLEVELAND ABBE.

Washington, July 30.

A Lunar Rainbow.

WET Mountain Valley in Colorado is situated some 8000 feet above the sea, and is surrounded by mountains, the Sangre de Cristo Range, on the western side, rising to some 14,000 feet in its highest peaks. For the last few days we have had a succession of thunderstorms—dark clouds pouring forth abundant rain—which have mostly swept along the range, leaving the valley clear, and often in sunshine. Last night, at 9 p.m., there passed just such a storm, while the full moon shone brightly from the east, where it had just risen. The result was a lunar rainbow—part only of the arc, a distinct band of light, in which the several colours were hardly to be observed. The phenomenon, which was new to me and must surely be rare, lasted only about a quarter of an hour, when the storm passed on.

West Cliff, Colorado, July 25. T. D. A. COCKERELL.

GLOBULAR STAR CLUSTERS.

PHYSICAL aggregations of stars may be broadly divided into "globular" and "irregular" clusters. Although, as might have been expected, the line of demarcation between the two classes is by no means sharply drawn, each has its own marked peculiarities. We shall limit our attention, in the present article, to the first kind.

The particles of a drop of water are not in more obvious mutual dependence than the components of these objects—"the most magnificent," in the elder Herschel's opinion, "that can be seen in the heavens." Were there only one such collection in the universe, the probability of its separate organization might be reckoned "infinitely infinite"; and no less than one hundred and eleven globular clusters were enumerated by Sir John Herschel in 1864. It does not, however, follow that the systems thus constituted are of a permanent or stable character; the configuration of most of them, in fact, points to an opposite conclusion.

There may, of course, be an indefinite number of arrangements by which the dynamical equilibrium of a "ball of stars" could be secured; there is only one which the present resources of analysis enable us distinctly to conceive. This was adverted to, many years since, by Sir John Herschel. Equal revolving masses, uniformly distributed throughout a spherical space, would, he showed, be acted upon by a force varying *directly* as the distance from the centre. The ellipses described under its influence would then all have an identical period: whatever their eccentricities, in whatever planes they lay, in whatever direction they were traversed, each would remain invariable; and the harmony of a system, in which no perturbations could possibly arise, should remain unbroken for ever: provided only that the size of the circulating bodies, and the range of their immediate and intense attractions, were insignificant compared with the spatial intervals separating them ("Outlines of Astronomy," 9th ed., p. 636).

But this state of nice adjustment is a mere theoretical possibility. There is no sign that it has an actual existence in Nature. The stipulations, upon compliance with which its realization strictly depends, are certainly disregarded in all stellar groups with which we have any close acquaintance. The components of these are neither equal, nor equally distributed. Central compression, more marked than that due simply to the growth in depth inward of the star strata penetrated by the line of sight, is the rule in globular clusters. The beautiful white and rose-tinted one in Toucan shows three distinct stages of condensation; real crowding intensifies the "blaze" in the middle of the superb group between η and ζ Herculis; in other cases, the presence of what might be called a nuclear mass of stars is apparent. Here, then, the "law of inverse squares" must enter into competition with the "direct" law of attraction, producing results of extraordinary intricacy, and giving rise to problems in celestial mechanics with which no calculus yet invented can pretend to grapple.

Sir John Herschel allowed the extreme difficulty of even imagining the "conditions of conservation of such a system as that of ω Centauri or 47 Toucani, &c., without admitting repulsive forces on the one hand, or an interposed medium on the other, to keep the stars asunder" ("Cape Observations," p. 139). The establishment, however, in such aggregations of a "statical equilibrium," by means of this "interposed medium," is assuredly chimerical. The hypothesis of their rotation *en bloc* is countenanced by no circumstance connected with them. It is decisively negatived by their irregularities of figure. These objects are far from possessing the sharp contours of bodies whirling round an axis. Their streaming edges betray a totally different mode of organization.

Globular clusters commonly present a radiated appearance in their exterior parts. They seem to throw abroad feelers into space. Medusa-like, they are covered with tentacular appendages. The great cluster in Hercules is not singular in the display of "hairy-looking, curvilinear" branches. That in Canes Venatici (M 3) has "rays running out on every side" from a central blaze, in which "several small dark holes" were disclosed by Lord Rosse's powerful reflectors (Trans. Roy. Dublin Society, vol. ii. p. 132, 1880); showing pretty plainly that the spiral tendency, visible in the outer regions, penetrates in reality to the very heart of the system. From a well-known cluster in Aquarius (M 2), "streams of stars branch out, taking the direction of tangents" (Lord Rosse, *loc. cit.* p. 162). That in Ophiuchus (M 12) has stragglers in long lines and branches, noticed by the late Lord Rosse to possess a "slightly spiral arrangement." Herschel and Baily described a remarkable group in Coma Berenices (M 53) as "a fine compressed cluster with curved appendages like the short claws of a crab running out from the main body" (Phil. Trans., vol. cxxiii. p. 458).

We find it difficult to conceive the existence of "streams of stars" that are not *flowing*; and accordingly the persistent radial alignment of the components of clusters inevitably suggests the advance of change, whether in the direction of concentration or of diffusion. Either the tide of movement is setting inward, and the "clustering power" (to use Sir William Herschel's phrase) is still exerting itself to collect stars from surrounding space; or else a centrifugal impulse predominates, by which full-grown orbs are driven from the nursery of suns in which they were reared, to seek their separate fortunes, and lead an independent existence elsewhere. It would be a childish waste of time to attempt at present to arrive at any definite conclusion on so recondite a point; but if the appeal to "final causes" be in any degree admissible, it may be pointed out that mere blank destruction and the