moved from the other half of the plate. The telescope was now so placed that the sun should be hidden behind a paper disk, fixed at about twenty feet distant. A diaphragm of one centimeter aperture was placed in front of the lens, and an exposure of four seconds given to the sky. On development, half of the plate, except where cut by the image of the disk, was found uniformly darkened. On the other half were four images of the sun, two of which were lighter, and one darker, than the sky. The third image of eight seconds exposure was of exactly the same darkness as the sky; and it was accordingly shown, that since the diaphragm used with the sky was about four thousand times larger, the sun was about two thousand times as bright, photographically, as the sky in its immediate vicinity. A number of plates were taken on different days, when the sky seemed perfectly clear, and the results indicated that the number varied in general between a thousand and four thousand. Owing to the diffraction produced by the small diaphragm used in photographing the sun, which rendered the image 1.6 times larger than it really should be, all these figures must be multiplied by 1.6.

Comparisons were then made in a similar manner between the sky near the sun, and the full moon, the latter taken with the full aperture of the lens, 3.65 centimeters, and the former with an aperture of .204 centimeter. Under these circumstances, with exposures of fifteen seconds, the moon and sky darkened the plate to about an equal amount. The result of a number of experiments indicated that the sky in the immediate vicinity of the sun was of about four hundred times the intrinsic brilliancy of the full moon. The ratio of the sky to the sun on this same day was fifteen hundred, so that the light of the moon was to that of the sun as one to six hundred thousand. In some experiments which I made in 1879,[1] I found the visual ratio was one to three hundred and fifty thousand. On account of the extreme blueness of the sun, it was to be expected that the photographic ratio should be somewhat higher than the visual one.

I next tried comparing directly the light of the sun and moon on the same plate, in order, if possible, to get a check on my results. The results, however, were unsatisfactory, the ratio coming out as 1 to 300,000, or only one-half the former amount. Owing to the difficulties of the experiment, this discrepancy may very well be referred to inaccuracies of the photographic plate, and changes in the sun's and moon's light during the course of the experiments. In all the results with regard to the sun, it must be remembered that the figures must be multiplied by 1.6, on account of diffraction. The two ratios, then, of the light of the moon to that of the sun, stand as 1 to 960,000, and 1 to 480,000; and of these, I think, in connection with my visual result, the former is the more correct figure. The moon at the time of these observations, June 26, 12 M., had an altitude of 29°, when the atmospheric absorption would amount to about twenty per cent.[1] Making this correction, we have the photographic ratio of the moon to the sun, as 1 to 760,000, or about twice as great as that to the eye. This is, of course, only an approximate result, as only very few observations were made, and as it was entirely outside the course of our inquiry.

Returning, then, to our original subject, we found the sky near the sun 400 times as bright as the full moon. Correcting for atmospheric absorption, this figure becomes 320 times. But we found before, that in order to detect the contrast between a coronal ray and a neighboring rift, the light of the sky must not exceed that of the full moon. It therefore seems that even in the clearest weather the reflected light of the atmosphere is 300 times too strong to obtain the faintest visible image of the true coronal rays.

In connection with these experiments, I took a few photographs of the sun with my improved apparatus. In order to still further diminish the reflection of the light from the surfaces of the lens, I so placed the telescope that the sun was almost completely hidden behind the high steeple of a neighboring church. A vast improvement in the results was at once obtained. The sun stood out sharply defined on a perfectly uniform background of blue sky. There was not the slightest trace of a fringe either where the steeple crossed the disk, or where the sky came in contact with the solar limb. The day was beautifully clear, and at six in the afternoon some more photographs were taken; but now, although the steeple was as clear as ever, all around the limb of the sun appeared the atmospheric halo, extending out in all directions, and gradually growing fainter as it receded from the sun. We may, therefore, in general, say, that with properly constructed apparatus, in perfectly clear weather, no halo whatever appears around the sun. It is only in slightly hazy weather, or as the sun approaches the horizon, that the appearances are produced which have been elsewhere described.

In brief, the result of my researches would seem to indicate, 1°; that without a total eclipse it ought to be impossible to photograph the solar corona, 2°; having tried, I have failed to photograph the corona, but have obtained the result which theory indicated.

WM. H. PICKERING.

[1] *Proceedings of the American academy of arts and sciences*, 1880, p. 246.

STEINEN'S EXPLORATIONS OF THE XINGU.

DR. KARL VON STEINEN has recently made a most interesting report of his explorations in the Matto Grosso,— the immense region, more than four times as large as France, which occupies a large part of central and western Brazil, and is hardly known to geographers except in the most imperfect manner. It is divided by great rivers, of which the Madeira, the Tapajos, the Xingu, the Araguaya, and the Tocantins flow northward, and the Paraguay flows southward. It is watered by innumerable streams which unite with these rivers, along whose banks live thou-

[1] *Annals Harvard college observatory*, vol. xiv. p. 62.

sands of the most primitive human beings. Steam-navigation exists on the Tapajos and Tocantins, and a railway is constructing along the banks of the Madeira. The Xingu is, however, almost unknown. Previous explorers have not reached beyond 4° south latitude, beyond which were supposed to be fierce tribes of cannibals. The primitive inhabitants of Brazil, retiring before the whites, were supposed to have concentrated themselves here as in a last stronghold. Between Piranhaquara and Paranatinga the river was absolutely unknown; and the existence of a water-way for trade to Para is a matter of the utmost importance to the inhabitants of the Matto Grosso, now confined for commercial purposes to the Paraguay.

The first part of the journey was made by land, and the latter part on the river. The military force commanded by Paula Castro worked with the civilians in perfect accord. They left Cayaba May 26, passing through the region of the Baicairis (partially civilized and friendly Indians), and after some delays, caused by the fact that the real distance was one-half greater than shown on the maps, they crossed the Paranatinga July 5, 1884, entering the unknown region, and travelling westward. The plain is a vast desert with an altitude of some twelve hundred feet, above which rise dunes of red sand and decomposed gravel to a further height of from two hundred to three hundred feet. The water was good, the grass very tall, but trees scarce and low, the vegetation being chiefly near the streams. Tapir and deer were seen, and a few birds, but the fauna is scanty. At mid-day the temperature was 80° F., but during the night it fell to 45°, and the party found great difficulty in obtaining game enough for food. Twenty leagues east from Paranatinga they found a river which they decided must be the Xingu. Making bark canoes, they began to descend it, meeting great difficulties: the river seemed to contain more rolling stones than water. In nineteen days, when they met the first Indians, they had passed more than a hundred rapids and four cataracts, of which one was fifteen feet high. Seven canoes were destroyed or wrecked: only six remained. Their provisions were almost exhausted, their clothing in rags, shoes worn out, and the men depressed by Malaria and the labor of frequent portages, when everthing had to be carried on their shoulders around rapids. Aug. 30 they arrived at the mouth the Batovi, and had reached more level country. Here three large rivers unite to form the Xingu, which is about a quarter of a mile wide. Numerous distinct tribes are located in this vicinity, all in about the same stage of culture. Surprised by the advent of the whites, they offered no hostilities, though fierce and untamed. They knew nothing of fire-arms. The reflection of the sun by a mirror alarmed them. One band of Suyas proposed a joint expedition against the Trumais, with whom they were at war. The Trumais live in villages of high round huts, several families in each. They cultivate manioc, maize, potatoes, and cotton, smoke wild tobacco, but do not know the banana. They do not hunt much, but shoot fish with arrows, and net them in pools. They have no spears, but kill wild animals with bow and arrow. They regard the flesh of the capybara as a delicacy, but do not eat that of the tapir or deer. Monkeys are eaten, their flesh dried and smoked for future use. They were much afraid of the dogs with the expedition: only one tribe had a name for this animal. The men go naked; they wear, however, strings of ornaments, teeth, shells, or nuts around the neck and waist, and a sort of cotton ribbon on the arms and legs. The women of most tribes wear a clout made of palm bark which could be put in a match-box. The Suya women wear absolutely nothing, although they know how to weave cotton hammocks, and make a sort of cordage of vegetable fibre. They do not know metals: all their tools are of bone and stone. Buttons were extremely desired. Steinen thought that with a gross of buttons he could have bought a house, field, food, and several wives. They are well proportioned. They practise the tonsure, shaving the crown with a very hard, sharp leaf resembling grass. They wear two feathers in their ears, and a diadem of feathers or straw. They play the native flute agreeably, and are fond of music. They ornament themselves at their feasts with bijous made of cotton or straw, or carvings of wood representing birds. In the houses are hung figures of animals coarsely plaited of straw, with some artistic merit. The Suyas, of whom only about a hundred and twenty were seen, are the terror of the other tribes. They are of greater stature, though absolutely nude, and wear a labret in the lower lip, and straw ornaments in the ears which reach to the shoulder. They cut the hair in front, and leave it long behind. They make baskets, hampers, and boxes of straw, and very perfect carvings of birds in wood. Their flute has three pipes of graduated size. They fight with heavy clubs ornamented with inlaid shell.

After leaving these people, another series of difficult rapids was encountered. The party were reduced to severe straits, were obliged to live on fish, two pumas which were killed served as a delicacy, fever prevailed among them, and their clothing was almost gone. Below the rapids they encountered a friendly tribe, the Yurumas, who were entirely ignorant of the people farther up the stream. These Indians sold them new canoes, and furnished guides. At last, on the 13th of October, the weary explorers reached Piranhaquara, the first outpost of civilization, almost naked and exhausted, but without the loss of a single man.

They had demonstrated the inutility of the Xingu as a trade route, but they obtained most valuable geographical and other scientific data in their traverse of the unknown region.

GEOGRAPHICAL NOTES.

THE great work of Gen. Tillo on terrestrial magnetism in European Russia, has just been published by the St. Petersburg academy of sciences. All previous investigations have been laid under contribu-