and then, by the application of Kepler's law of relations between the celestial bodies as to distance, the grander, the colossal, and central problem of celestial mathematics is brought to the very edge of minute revelation.

This method of dealing with the great astronomical *opus* of centuries was recommanded by Edmund Halley; though, in honoring him for his foresight, we must not overlook the fact that James Gregory, at a still earlier day, suggested the probable feasibleness of obtaining the solar parallax through the knowledge of that of Venus by transit.

This knowledge might, perhaps, be reached by direct observation of the planet, at auy one of her nearest approaches to the earth, exactly as the parallax of the nearest exterior planet, Mars, has been calculated. Of these two results, however, the former would be much the less valuable and trustworthy, owing to the general absence—or, rather, to the invisibility—of contiguous stars, as accessories to careful measurements, in the proximate radiance of the sun. To get Venus, therefore, upon the sun's face, is to obtain this great primary advantage in attacking the evasive question of her precise parallactic displacement, that we have, as it were, behind her a dial-plate, and can make felicitous use of it in measuring the chords she traces upon it in her path.

This brief paper cannot pretend to deal with the minor embarrassments which belong inseparably to such observations. They are many, however, and require subtile processes for overcoming them. The compound and complex motions of both the planets—Venus and the earth—while the observations are making, are not slight hinderances to the work, although, of course, ultimately manageable.

Then, too, there are curious distortions of the little black spot, at the imminent moments of its entrance upon and departure from the sun's face, in which it presents much the appearance which a drop of water does when slowly lifted from a larger volume at the end of a rod. The planet assumes a sort of pear-shape, which is, indeed, an optical illusion, but in this case a very serious one, since it makes it uncertain, for an important moment, whether the edge of the planet is actually clear of the sun's absolute edge or not.

This phenomenon, slight as it seems. as a disturbing feature and force, actually tended to invalidate the laborious processes and calculations of the experts, who, at Kola, in the Arctic Seas, at Pekin, at Otaheite, and other points, made sedulous search for the solution of the parallactic problem in 1769.

Doubtless, Venus will deport herself in the same eccentric, if not unbecoming, fashion in 1874; but the astronomers will not again be taken in by it. They had, indeed, eight year's warning after her first strange antics in 1761, before they were renewed in 1769, but in all that timely interval they were. unhappily, not considered and provided for as they have been since. Venus can stand upon the sun's brink like a black peg-top on its point, or a pear upon its stem, if she will, but the observers will be able now to tell to a second when to count her wholly within the solar rim.

One method of observing the transit—and that, too, the general method which the English expeditions will pursue (but whether with the best judgment or not is perhaps fairly questionable)—is a modification of Halley's plan, and known as Delisle's method. It deals with the planet just at the beginning or end only of the transit. Two observations, one made at the earliest observable beginning-point. and another, on the earth's opposite border, at the latest beginning-point—or equally well if the ending-points are chosen—will give the sun's parallax. Exactness of comparative time in these remote observations is the thing essential here, and this is not easily assured.

Halley's method, on the other hand, deals with Venus in the actual transit—measuring its precise period and the chords she traverses, as noted at such nearly antipodal points of the earth as are available for the view. Sometimes the best points are in the sea, or in other impracticable positions. All these things combine with time-difficulties to make the work of transit-taking always most delicate in detail, and sometimes most doubtful in decision.

Yet the eagar explorers of the celestial depths, accustomed to deal with apparently overwhelming tasks, subject them to law, to exactness of condition, to uniformity of result; and thus what would otherwise seem insuperable, falls—if not easily, yet eventually—under the control or human genius, skill, and persistence.

The present accepted parallax of the sun, as obtained, not hy transit calculations, but by most patient processes, which have beguiled no meagre portions of the weary interval since Venus obliged the astronomical college with a sight of herself in the *rôle* of a blackamoor, is 8''.9, and this formula, mathematically translated, means 91,730,-000 miles, with a chance for error somewhere within the hundreds of thousands, and of which possible error we may not reasonably hope to get any further contraction until the next transit of Venus comes off.

Of other processes, herein referred to, some are so beautiful and ingenious that the reader will be willing to linger for a glimpse of them. One, indeed, has been mentioned already—the direct observation of Mars; which red-atmosphered globe sometimes comes almost as nigh to us as Venus, and, from its position among the stars, is a good auxiliary in this problem-work.

Another is the extraordinary and daring plan of estimating the sun's distance by experimental tests of the amazing speed of the light-ray. This speed, as usually stated, of 192,000 miles in a second, is only in a sense conjectural, and really affected by the one great doubt we are dealing with. When the sun's distance is determined, the actual velocity of light will be settled with it.

Yet bold physicists have come independently to something like certainty in estimating the rate of the motion of light. Foucault and Fizeau. by measuring the duration of visual impressions—the one by means of rotating mirrors, the other by rotating toothed wheels—have given us figures for this problem. Foucault's calculation, indeed, was deemed scientific enough to cast doubt upon the distance-problem as it stood. He made the speed of light something short of 186,000 miles a second, which would reduce the sun's distance several thousand miles below the latest accepted data.

Again, irregularities in the motion of both the earth and its satellite have been ingeniously and hopefully levied upon for tribute to the growing grandeur of the resources in the hands of the astronomer, for yet vanquishing the formidable foe holding back from him so long this important secret of the sun's real distance from the earth.

These investigations, pressed with so much pains, patience, and persistence, are indisputable proofs of the unfaltering and invincible spirit of modern science, which will not accept uncertainties, unless in conditions which clearly render them finally inevitable.

WILLIAM C. RICHARDS, in Appleton's Journal.

Theory and Practice in the School-Room. (*)

Teachers who year after year have met in this room to compare notes, have by this time, I doubt not, in almost

(*) Paper read by C. G. K. Gillespie, Esq., Secretary, before the College of Preceptors, London, at the evening meeting of 8th February, 1871.