fills the universe, which is not imponderable, but has indeed been weighed, and must have a quality answering to extreme rigidity or incompressibility—for if yielding it could not transmit a pulsation with rapidity. The weight of the sphere of ether, of which the earth's orbit is a circumference, is placed at 4,400,000 tons, by Mr. J. M. Clark (Trans. Can. Institute, October, 1891). There are many ways in which the velocity of light can be measured, the easiest being that connected with the eclipses of Jupiter's moons. We know the mean times at which these eclipses should happen: also approximately the distance of the earth from the sun. Now it is manifest that when the earth is on the side of the sun nearest to Jupiter it is a whole diameter of the orbit nearer to that grand planet than when it is on the side farthest from Jupiter. The farther it is off the later these eclipses appear to be; the nearer it is, the earlier. Hence the time needed for light to traverse the orbit of the earth is easily noted, and it is about 16½ minutes corresponding to 186,000 miles, or 300,000 kilometres a second. Now the number of luminous vibrations must be enormous; in inverse proportion to the tenuity of ether and the velocity of light. Also the length of the light waves must be very small. And as colours correspond to sounds, each colour having—like each sound—a different wave length, so we find that red corresponds to four hundred millions of millions of vibrations per second, while violet corresponds to seven hundred and fifty millions of millions. So the wave length of red is seven ten-thousands of a millimetre or, say, one three hundred thousandth part of an inch; that of violet larger or, say, sixteen or seventeen one millionth parts of an inch.

The other simple colours are intermediate between these, and as for the compound colours, they are like compound sounds. As in the sounds of a fiddle string, of a flute or of a bell you do not get the simple sound, but the sound modified by various harmonies, due to the instrument, which change its character and so differentiate to the ear the peculiar tone of the violin, the flute, the bell—so with colours, the different vibratory motions of each can superimpose themselves and give rise to a resultant vibration which produces through the eye the impression of a compound colour.

The well-known phenomena of the colourings of a soap-bubble are thus to be explained. Light strikes the bubble and is reflected both from the exterior and interior surfaces of the tenuous film. The light which comes back from the inside of the film has twice traversed its thickness, and is therefore so much *behind* that which is reflected from the outside. The waves do not usually interfere at first, and no colour is visible, the walls being thick and in movement. Shortly, by evaporation, they get thinner and restful, showing in patches successively red, orange, green, blue and violet; then the bubble bursts. If the thickness of the bubble is equal to half-a-wave length or an odd number of half-wave lengths, there will be interference, *i.e.*, extinction of light; if to an even number there will be a reinforcement of the colour to which those particular wave-lengths are due. To the differences in thickness we therefore owe the differences in colour of the bubbles.

If then we place a reflecting surface, a mirror, behind a sensitized film, and expose it in the camera, focussed on a red object, the reflected rays must "interfere" with the direct rays, and the thickness of the film will be divided into just so many parallel sections as there are semi-wave lengths of red therein. There will be just so many parallel planes of dark points at which the nodes of interference occur, and so many planes of illumination at which the ventral curves have their greatest extension. If the film be 1000th of an inch in thickness, there will be three hundred such parallel planes of red-darkness, and three hundred of red-light maxima. Of course, as sound re-inforces sound, as three hundred voices attuned alike are louder than one, so there is a re-inforcement of the red-light by this multiplication of planes reflecting red. The same with other colours; a violet object will in the same film produce 160 or 170 such planes of wave-nodes and ventral maxima, and if we expose the spectrum to the plate, or I should say the plate to the spectrum, we shall have each colour producing, by reflection, its separate series of such strata.

We now use in photography what is called a dry plate; that is, a pane of glass, covered with a film of collodion, gelatine, or albumen, soaked in a solution of iodide or bromide of silver, and dried . . . of course in the dark. When the light strikes it the most brilliant rays decompose the translucent silver-salt, and particles of metallic silver are formed which render the plate more or less opaque. These particles are finer than the matter which colours the smoke of a cigar, but the numbers of them in the film produce opacity—more or less according to the intensity of the light and the time allowed for decomposition. If anyone has not seen a photographic negative, he will find it worthy of his inspection. Now it would seem that if we were to place a mirror behind an ordinary dry plate we should produce the effect of colour without more ado, and I incline to the belief that this is possible, if we were to work with care and choose special plates. However it is found that in drying the substance of these films granulates and the grains are large enough to traverse several of the layers of silver particles which form *in the planes of the semi-wave length ventral maxima*, thus breaking up their continuity. So a wet plate has to be resorted to; one coated with both collodion and albumen by the Taupenot process is preferred. This film contains some haloid of potassium, either a chloride bromide or iodide, but bromide gives the best results. Plunged in a 10 per cent. solution of nitrate of silver, bromide of silver is formed within the substance of the film, and our thus sensitized plate is ready.

We must now choose our mirror. A surface of silver would be immediately dimmed by the chemicals from the film, so a surface of mercury has been resorted to. A holder is prepared, quite mercury tight. The plate is put in the groove of the holder, which thus forms a box, the sensitive film *inside*, the mercury is then poured in, and the surface remains bright long enough to permit the completion of the process.

Here, however, we are met by the difficulty of the very different actinic power of the rays of differently coloured light. Red has so little effect on silver salts that photographers "load" their plate holders by ruby-light and develop by it too. Yellow light is nearly as innocuous, and if you have a red and a yellow pane, superimposed, in your dark-room window, you can almost defy the light to touch your plate at all. By way of completing the parallel between sound and colour, let me add that there are chemical effects below the visible colours of the spectrum-band; resembling the unheard bass of the waterfall and the unheard treble of the sandfly's wing.

If then we gave our plate only enough exposure to bring out the violet and blue tints, we should not have given it enough to bring out the yellows and the reds, while if we had given it enough to bring out the reds and yellows, we should have over-exposed it with respect to the blues and violets; it will therefore be "fogged" as to these—or they will come out black from over exposure.

So Professor Lippmann resorted to the use of coloured screens. Putting before his lens a solution of helianthime, contained in a flat glass vessel with exactly paralleled sides, he shut out all rays excepting red. When the red rays had produced their due effect, he removed the red screen, and by a yellow solution of bichromate of potassium he let in red and green, still excluding blue and violet. Having allowed time for the green rays to do their work, he removed the screen and thus the blue and violet almost instantaneously (by comparison) affected the plate.

Professor Lippmann found that while two hours were necessary for the red rays to produce their full effect, twenty minutes were enough for the green, and one or two minutes for blue and violet. In his first experiments he necessarily restrained the sensibility of his plates. In later practice, he reduced to ten minutes the time of exposure to red light, and at last by dipping in cyanine the sensitized plates, he prepared plates as sensitive to red as to blue, so that he has lately been able to photograph in six minutes a complete spectrum, without having recourse to screens at all.

The spectrum was that produced by an 800 candle power electric light. By concentrating such a spectrum with a lens, it was recently photographed in two minutes by Mr. Molteni, before the Photo. club of Paris, and I hope, next year, to repeat the experiment before this Society.

The development of the plate thus obtained demands a moment's attention. The image is of course latent when the plate is removed from the camera. It is plunged into a bath of pyro-gallic acid and sesqui-carbonate of ammonia. When the image becomes visible, in black, it is fixed in weak hyposulphate of soda, well washed, and set out to dry.

Then comes the magical apparition of the colours, each tint appearing in due sequence; a magnificent sight which it is said those cannot fully appreciate who have not been privileged to see it.

The film being swollen by the washing, the red has its planes of colour too far apart to reflect colour of any kind, while the planes due to violet wave-lengths are so far separated from each other that they reflect a red. As the drying proceeds, the red shifts towards its proper place, and in its stead, the green appears, which in its turn gives way to blue, and finally when the plate is dry, the violet shows its lovely tint at one end, while the red has taken up its position at the other, to which it legitimately belongs.

If the plate is under developed, it can be intensified, like any other—but you must use acid, not mercury bichloride, because it thickens the deposit between the planes or layers, and by thus changing their distance apart, destroys the coloration. If you look at the plate by transmitted light, you will, of course, see the complementary colours. In either case the colour can best be observed by diffused light, that is, under a shade such as that given by an awning.

The film can be removed from the glass plate, and transferred to white cardboard by the ordinary method.

I have, perhaps, been somewhat prolix in this account of the mode in which Lippmann has imprisoned colours in the film of gelatine—as Edison fixed sound on the surface of his cylinder of mineral wax. I have, however, condensed a good deal the accounts of the inventor and of his friend, M. Alphonse Berget, which have been published in the *Revue Scientifique*.

They are both justly proud that this discovery belongs to France, the country of Daguerre, and I think myself that the world is now apt, not to overvalue the Germans, but to undervalue the French scientists, whose logical methods and precision of argument and process are worthy of all praise and imitation. Paris still deserves, I believe, the eulogium of our Bulwer Lytton: "*O, mon Paris—foyer des idées et œil du monde.*" Oh, my beloved Paris, birthplace of thought, eye of the world! It remains for experience to suggest improvements, and I have brought the matter forward here that Canadians may be thinking of it, too. It has occurred to me that a polished plate of aluminum might be used instead of the mercury, and it is possible that a coating of mercury and tin put upon the reverse of a plate in the usual inexpensive method of looking-glass factories, and then prepared, may give good results. I am, however, far from thinking that a landscape or a portrait taken in colours by photochromy would be artistically pleasing, even as the motions of horses, or of athletes, taken on the instantaneous plate, are not satisfactory to the eye.

MAIDENLY MODESTY OR IMMODESTY IN SHAKESPEARE'S TEMPEST.

CHARLES LAMB'S well-known pleading, in his essay on Shakespeare's Tragedies, for the reading of these plays rather than their acting is supported by a French writer in a recent number of *La Revue Bleue*, who has not words strong enough for the genius, the richness of the poetry, the profundity of thought in "Hamlet," which yet his French judgment does not hesitate to pronounce to be a drama very badly constructed for the stage.

However, that by the way.

But another reason given by M. Jules Guillemot against acting Shakespeare is, that his work "is full of obscenities which it is impossible for us to admit in our theatres."

Now, it is quite true that there is a rougher giving of busses by Falstaff, and a coarser brutality of sneering by Iago than can be found in plays of Molière: not to speak of the English Restoration drama whose outrageous characteristics are in such striking contrast to the absence of such in the French drama of that or indeed of any period. The contrast is best shown, and in all its monstrosity, when placing—for instance—Wycherley's "adaptation" of "Le Misanthrope" side by side with the original: and one might illustrate this contrast by Dryden's "adaptations" of "The Tempest" and "Paradise Lost." But when all is said, not only of Shakespeare's plays, but even of those of the Restoration dramatists, one has to keep in mind habits of thought, and customs of time and place: Is there not the account of Cowper reading "Jonathan Wild" to quiet pious ladies, and causing no flutter nor distress; and did not a noble old Scottish dame tell Sir Walter Scott that in her young days even Mrs. Aphra Behn's comedies were read aloud to mixed companies of decent men and women; not without offence surely in one sense, yet the mere reading not being held an offence?

Apply all that with ten-fold force to Shakespeare. And may one not say that if we could without offence read out "Othello" we should be all the better for it. If purity and prudery are not as often enemies as allies, then not only dramatists and satirists, but moralists, and even ascetics such as Cardinal Newman, are very wrong in many of their explicit statements. To be sure it is a different question.

But going further, and not taking into account differences of time and place at all, is it not astonishing to find a critic going on to find obscenities in Miranda, no matter when or where she is made known? M. Guillemot continues: "The sweet Miranda, one of the most exquisite heroines of Shakespeare, whom many of those who profess to be admirers of the poet know as much about as they know of the province of Kiang-Sow in China, converses with Prospero and Ferdinand in a way that Zola would not have dared to make Gervaise use with Coupeau."

No doubt Juliet and Miranda and Desdemona herself married their husbands to live with them in joys of body as well as in communings of spirit, and expressed the enthusiasm and longing that is in true marriage when there is the belief that two natures can really be united, and that with animal passion in mankind there can go the absolute consecration of mind and heart: Desdemona was not the shameless sceptic declaring lust and love to be one and the same thing; like Iago, and like some of her respectable shocked critics among modern men and women, be they hypocrites or mere unbelievers. It is well, no doubt, therefore, to remind us that Miranda is of flesh and blood.

But here let her speak; and could the reader of fullest worldly knowledge and experience find obscenities—one asks pardon for the word—in what she says?

> 'I do not know
> One of my sex; no woman's face remember,
> Save, from my glass, mine own; nor have I seen
> More that I may call men than you, good friend,
> And my dear father: how features are abroad,
> I am skilless of; but by my modesty,
> The jewel in my dower, I would not wish
> Any companion in the world but you,
> Nor can imagination form a shape,
> Besides yourself, to like of. But I prattle
> Something too wildly and my father's precepts
> I therein do forget."
> "Do you love me?" she asks Ferdinand;
> Who answers as a true man, saying not only
> "I love," but "I prize and honour."
> *Mir.* I am a fool
> To weep at what I am glad of.