of this new star with the Eastern Equatorial of the Paris Observatory. On the first evening of observation I was only able to establish the presence of bright lines in the spectrum, two days after the atmospheric conditions enabled me to make a more thorough examination, and to take measurements as exact as the feeble light of the star permits. The following is the result of the spectroscopic investigations:—

The spectrum of the star is composed of a certain number of bright lines standing detached on a sort of luminous background, almost completely interrupted between the green and the blue, so that at first sight the spectrum appears to consist of two separate parts. In order to study it qualitatively, I made use of a spectroscopic eye-piece, specially constructed, which utilises the greatest portion of the light, and allows us to vary its concentration. For the measurements I employed a Duboscq direct-vision spectroscope, fitted with a scale visible by means of lateral reflection. The accompanying sketch gives an idea of the appearance of the spectrum, and represents the position of lines measured according to the readings of the auxiliary scale, in the most complete series of measurements.

I have only noticed bright lines; the dark lines, if they exist, must be very fine and must have escaped me on account of the very feeble light of the star. The order $\alpha\,\beta\,\gamma\,.\,.\,.\,\theta$ is that of their intensity, taking into account the visibility of the colour. The following figures are the divisions of the scale which define their position:—

α	δ	γ	β	ζ	η	θ	ϵ
30	44	60	66	73	81	100	113

The flame of a spirit lamp, observed immediately after, gave the line D at the division 42; but a slight obliquity of the slit relatively to the lines of the scale, introduces a constant difference of one to two divisions in the direction of the re-establishment of the coincidence with the line δ.

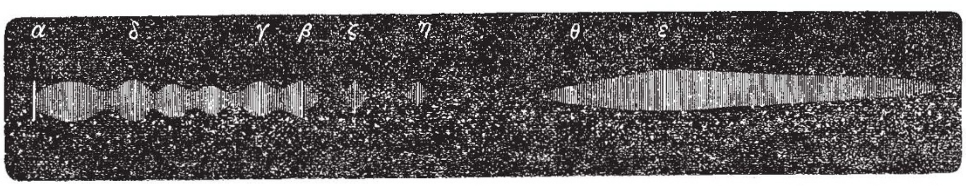
The sky being covered soon after that measurement, I left the spectroscope in position without touching it, and next morning I compared the position of the Fraunhofer lines visible with the light of the clouds:—

C	D	*b* (mean)	F	G
31	43·5	65·3	79·5	116

This is the spectroscope which I employed to observe the spectrum of the Aurora Borealis of February 4, 1872. The relative distance of the lines C, D, F, was the same, 21, 33, 69. There may easily be deduced from these data the correspondence of the divisions of the auxiliary scale with the scale of wave-lengths. The following are the results calculated for the bright lines observed, as also a table of bright lines of various elements expressed in millionths of a millimetre:—

	α	δ	γ	β	ζ	η	θ	ϵ
Observ. ...	661	588	531	517	500	483	451	435
Hydrogen ...	656(C)	—	—	—	—	486(F)	—	434
Sodium ...	—	589(D)	—	—	—	—	—	—
Magnesium...	—	—	—	517(*b* mean)	—	—	—	—
Line in Solar Corona ...	—	—	532	—	—	—	—	—
Line in Chromosphere..	—	587	—	—	—	—	447	—

This comparison shows that if we take into account the small apparent displacement caused by the obliquity of the slit (which makes all the numbers a little too large), and the inevitable uncertainty presented by measurements of such feeble lights, it may be admitted that the lines α, η, ϵ, coincide with that of hydrogen, δ with that of



sodium, and β with the triple line *b* of magnesium. The feeble dispersing power of the spectroscope used did not enable me to distinguish whether the bright line was single, double, or triple, for any of the three cases may occur (*Comptes Rendus*, t. lxxiii., p. 332).

But the most curious coincidence, which I give here with much reserve, but which it will be interesting ultimately to verify, is the coincidence of the line γ, very bright in the spectrum of the star, with the green line $\lambda = 532$ (1474 of Kirchhoff's scale), observed in the spectrum of the solar corona and in the chromosphere; the feeble band θ corresponds also to a band $\lambda = 447$ of the chromosphere; one is thus led to think that the line δ corresponds rather to the bright line of the chromosphere $\lambda = 587$ (helium), than to that of sodium, 589. If this interpretation be accurate, the bright lines of the spectrum of the star comprehend exclusively the brightest and most frequent lines of the chromosphere. The following, in fact, according to Young's Catalogue of the Chromospheric Lines (*Phil. Mag.*, November, 1871), is the designation of the brightest lines and their relative occurrence:—

Wave-lengths	656(C)	587	532	517(*b*)	486(F)	447	434
Relative frequence ...	100	100	75	15	100	75	100

All the other bright lines have a relative frequency lower than 10, with the exception of the fourth bright line of hydrogen $\lambda = 410$ (*h*), to the extreme violet, whose frequency is represented by 100. I believe, moreover, that I have often seen this line without always being able to measure it.

To sum up, the light of the star appears to possess exactly the same composition as that of the solar envelope known as the chromosphere. Notwithstanding the great temptation there exists to draw from this fact inductions relative to the physical condition of this new star, its temperature, the chemical reactions of which it may be the seat, I shall abstain from all comment and all hypothesis on this subject; I believe the facts necessary to arrive at a useful conclusion are wanting, or at least at a conclusion capable of verification. Whatever attractions these hypotheses may have, it is necessary not to forget that they are unscientific, and that, far from serving science, they greatly tend to trammel her.

JUST INTONATION

DR. STONE'S lectures on "Sound and Music," just published, lead one to expect that notwithstanding the formidable appearance of some of the key-boards exhibited at South Kensington, the cause of scientific music and of just intonation in particular will be materially advanced by the Loan Exhibition.

Certainly we may look for something practicable and little short of perfect in the "Natural Finger-board" of Mr. Colin Brown, the Euing Lecturer on Music in the Andersonian University, Glasgow. As supplementary to the descriptions given by Dr. Stone and by Mr. Brown himself, I trust the following remarks will help to elucidate the construction of the instrument, and to make still more obvious its simplicity and "naturalness."

The vibration numbers of the diatonic scale being represented by—

$$1,\ \frac{9}{8},\ \frac{5}{4},\ \frac{4}{3},\ \frac{3}{2},\ \frac{5}{3},\ \frac{15}{8},\ 2,$$

if we build the scale upon the dominant $\frac{3}{2}$ the vibration numbers will be—

$$1, \frac{9}{8}, \frac{5}{4}, \frac{45}{32}, \frac{3}{2}, \frac{27}{16}, \frac{15}{8}, 2,$$

and if we built it upon the subdominant $\frac{4}{3}$ the vibration numbers will be—

$$1, \frac{10}{9}, \frac{5}{4}, \frac{4}{3}, \frac{3}{2}, \frac{5}{3}, \frac{16}{9}, 2.$$

Or, more generally, if C, D, E, F, G, A, B, 2C, be taken to represent the vibration numbers of the so-named notes in the scale of C, then the vibration numbers of the scales on G and F will be—

$$C,\ D,\ E,\ \alpha F,\ G,\ \beta A,\ B,\ 2C,$$

$$C,\ \frac{1}{\beta}D,\ E, \natural F,\ G,\ A,\ \frac{1}{\alpha}B,\ 2C,$$

where

$$\alpha = \frac{135}{128},\ \beta = \frac{81}{80},$$

α and β being respectively the chromatic semitone and the comma. Here the law of the formation of the relative scales is so obvious that they can be written down successively at sight.

Now let the fifteen scales be written down from C to C♯ in the one direction, and to C♭ in the other, when it will be immediately apparent that the symbols are arranged in groups of threes and fours, and if we draw straight lines horizontal and vertical so as to enclose these groups each in a rectangle, we have at once the properly so-called "Natural Fingerboard," the rectangles being the digitals, of which the larger are white and the smaller coloured

Major Keys.								
C♯	$\alpha\beta C$	$\alpha\beta D$	$\alpha\beta E$	$\alpha\beta F$	$\alpha\beta G$	○ $\alpha\beta A$	$\alpha\beta B$	$2\alpha\beta C$
F♯	$\alpha\beta C$	○ αD	$\alpha\beta E$	$\alpha\beta F$	$\alpha\beta G$	$\alpha\beta A$	βB	$2\alpha\beta C$
B	$\alpha\beta C$	αD	βE	$\alpha\beta F$	○ αG	$\alpha\beta A$	βB	$2\alpha\beta C$
E	○ αC	αD	βE	$\alpha\beta F$	αG	βA	βB	○ $2\alpha C$
A	αC	D	βE	○ αF	αG	βA	βB	$2\alpha C$
D	αC	D	βE	αF	G	βA	○ B	$2\alpha C$
G	C	D	○ E	αF	G	βA	B	2C
C	C	D	E	F	G	○ A	B	2C
F	C	○ $\frac{1}{\beta}D$	E	F	G	A	$\frac{1}{\alpha}B$	2C
B♭	C	$\frac{1}{\beta}D$	$\frac{1}{\alpha}E$	F	○ $\frac{1}{\beta}G$	A	$\frac{1}{\alpha}B$	2C
E♭	○ $\frac{1}{\beta}C$	$\frac{1}{\beta}D$	$\frac{1}{\alpha}E$	F	$\frac{1}{\beta}G$	$\frac{1}{\alpha}A$	$\frac{1}{\alpha}B$	○ $\frac{2}{\beta}C$
A♭	$\frac{1}{\beta}C$	$\frac{1}{\alpha\beta}D$	$\frac{1}{\alpha}E$	○ $\frac{1}{\beta}F$	$\frac{1}{\beta}G$	$\frac{1}{\alpha}A$	$\frac{1}{\alpha}B$	$\frac{2}{\beta}C$
D♭	$\frac{1}{\beta}C$	$\frac{1}{\alpha\beta}D$	$\frac{1}{\alpha}E$	$\frac{1}{\beta}F$	$\frac{1}{\alpha\beta}G$	$\frac{1}{\alpha}A$	○ $\frac{1}{\alpha\beta}B$	$\frac{2}{\beta}C$
G♭	$\frac{1}{\alpha\beta}C$	$\frac{1}{\alpha\beta}D$	○ $\frac{1}{\alpha\beta}E$	$\frac{1}{\beta}F$	$\frac{1}{\alpha\beta}G$	$\frac{1}{\alpha}A$	$\frac{1}{\alpha\beta}B$	$\frac{2}{\alpha\beta}C$
C♭	$\frac{1}{\alpha\beta}C$	$\frac{1}{\alpha\beta}D$	$\frac{1}{\alpha\beta}E$	$\frac{1}{\alpha\beta}F$	$\frac{1}{\alpha\beta}G$	○ $\frac{1}{\alpha\beta}A$	$\frac{1}{\alpha\beta}B$	$\frac{2}{\alpha\beta}C$

Here all the scales are true and adjacent according to their relationship, the fingering obviously the same for all. The relative minors are provided for by a round digital in the corner of each coloured digital, bearing to it the vibration ratio of 15 : 16.

The intervals on the board as seen above express themselves: moving from flat towards sharp keys the interval from a white to a coloured digital is α, and from coloured to white β.

Between digitals related as αG (G♯) and $\frac{1}{\alpha}A$ (A♭), that is, between every pair similarly related in mutual azimuth (to borrow a term) and distance, the schisma occurs. The keyboard gives us the value of the schisma by inspection; we may either take the route—

$$\frac{1}{\alpha}A \text{ to } A = \alpha : A \text{ to } G = \frac{9}{10} : G \text{ to } \alpha G = \alpha.$$

giving schisma $= \frac{9}{10}\alpha^2$. Or thus—

$$\frac{1}{\alpha}A \text{ to } A = \alpha : A \text{ to } \beta A = \beta : \beta A \text{ to } \alpha G = \frac{15}{16},$$

giving schisma $= \frac{15}{16}\alpha\beta$. This expression shows that the schisma also exists between any round digital, and the coloured digital next below. Or we may get an entirely numerical value thus:—Since from white to white is 8 : 9, then from $\frac{1}{\alpha\beta}D$ diagonally to βA is $(8 : 9)^4$ and from βA back horizontally to αC, a minor sixth, is 8 : 5, the interval of αC and $\frac{1}{\alpha\beta}D$ is

$$\text{Schisma} = \frac{5}{8}\left(\frac{9}{8}\right)^4.$$

Again, the "comma of Pythagoras" being the excess of twelve fifths over seven octaves is expressed by—

$$\left(\frac{3}{2}\right)^{12}\frac{1}{2^7} = \left(\frac{9}{8}\right)^6 \cdot \frac{1}{2},$$

that is, it is the excess of six major tones over one octave. The keyboard shows this immediately; from $\frac{1}{\alpha\beta}D$ diagonally to $2\alpha\beta C$ is six major tones, thence back horizontally to $\alpha\beta C$ is one octave, therefore $\alpha\beta C$ differs from $\frac{1}{\alpha\beta}D$ by the "comma of Pythagoras." And every pair of white digitals (or coloured, as αD and $\frac{1}{\alpha\beta}E$) similarly related in azimuth and distance have the same interval. Obviously, by mere inspection of the board, the "comma of Pythagoras" is equal to comma + schisma. In fact this keyboard will well repay a very careful study.

Turning to the practical aspect of the subject, the harmonium on this principle must be considered "un fait accompli," judging by the highly appreciative interest shown by the South Kensington audience, who remained long after the close of the lecture to listen to the instrument which was exhibited, and played on.

When we count the number of wires that would be necessary for a piano, the prospect would be somewhat alarming, did we not remember that on account of the number of harmonics and sub-harmonics, or combination tones that would be called into play, probably one wire to each digital instead of two or three would suffice.

The original account of this key-board is given in the second of two small pamphlets entitled "Music in Common Things," by Mr. Colin Brown. In these the numerical basis of the diatonic scale as derived from harmonics is laid down with remarkable perspicuity, and amongst other things the reader will see, for the first time probably, that although the fourth and sixth of the scale are wanting as harmonics to the tonic, yet they come out in the diatonic scale as harmonics to the fourth of the scale. Indeed the seven notes of the scale come out successively as harmonics to Fa in the fifth and sixth octaves.

A. R. C.