A Note on the Constitution of the Sun

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Patrice Robitaille (TAV College, Montreal, Canada) provides a translation of Heinrich Gustav Magnus' classic work *Notiz über die Beschaffenheit der Sonne*, as it appeared in March 1864 within *Poggendorff's Annalen der Physik und Chemie*,1864, v.131, 510–512. The article had previously been translated into French: *Notice sur la constitution du soleil. Archives des science physique et naturelles (Genève)*, 1864, v.20, 171–175. This work formed the basis of the present translation. Heinrich Gustav Magnus (May 2, 1802 – April 4, 1870) was a professor at the University of Berlin and had studied in Paris under Joseph Louis Gay-Lussac. He would count amongst his students Wilhelm Beetz, Hermann Helmholtz, Gustav Wiedemann, John Tyndall, Rudolph Weber, and Adolph Wüllner (Heinrich Gustav Magnus, *Platinum Metals Review*, 1976, v.20(1), 21–24). In his *Notiz*, Magnus demonstrated that the addition of sodium hydroxide to the gaseous flame resulted in a tremendous increase in luminosity. Magnus' work would inspire Father Secchi to propose that the Sun was a gaseous globe whose photosphere contained condensed particulate matter (Secchi A. *Sulla Struttura della Fotosfera Solare. Bulletino Meteorologico dell' Osservatorio del Collegio Romano*, 1864, v.3(11), 1–3; English translation in *Progr. Phys.*, 2011, v.3, 30–32). Magnus' report on the constitution of the Sun would continue to impact solar physics for two generations.

Already in 1795, W. Herschel[*] advanced the idea that the Sun is formed of an obscure nucleus surrounded by an atmosphere or photosphere from which light and heat are emitted. Between this photosphere and the nucleus, he also admits the presence of a reflective atmosphere whose reflection prevents the light of the photosphere from reaching the nucleus. Arago[†] in exposing this hypothesis which he gives as generally accepted[‡], remarks that the photosphere determines the outer edge of the Sun, but that the photosphere is itself surrounded by a diaphanous atmosphere; he comes to this conclusion through the observation of the protuberances [flares and prominences] during total eclipses of the Sun. Herschel[§] says that the photosphere is neither liquid nor gaseous, but that it is made up of luminous clouds. According to our current knowledge of the radiation of light and heat, it is difficult to admit that the photosphere, from which solar heat emanates, does not heat to the point of incandescence the nucleus that it surrounds. The intermediate reflecting atmosphere, whose existence was assumed, could very well stop the passage of light but not the progressive heating of the nucleus. It is therefore with reason that Mr. Kirchhoff[¶] says that this hypothesis which was devised to explain sunspots, is in such total contradiction with our knowledge of physics, that we should reject it even if we cannot come to make comprehensible, in another way, the phenomenon of sunspots.

Mr. Kirchhoff was guided by his research on the solar spectrum to admit that the Sun consists of a solid or liquid nucleus, brought to the highest incandescence and surrounded by a diaphanous atmosphere with a slightly inferior temperature.

I do not know that we have as yet deduced from the nature of the heat that emanates from the Sun, a conclusion on its constitution; we could but mention the observations of Reverend Father Sechi[‖] relating that the poles emit less heat then the Sun's equator. Some of the experiments that I have conducted on calorific radiation, allow, I think, for new views on the constitution of this celestial body.

If we observe the heat that emanates from a non-luminous gas flame, and if we introduce a bit of sodium hydroxide which, as we know, renders it extremely luminous, we see at the same time, that the calorific radiation increases. The experiment was carried out in such a way that we were always comparing a predetermined place of the sodium hydroxide flame, with the same place of the non-luminous flame, and this in such a way that the sodium hydroxide introduced into the flame, could not radiate over the thermo-electro battery used for observation. Evidently, in this case, part of the heat of the flame was used to bring to incandescence or to vaporize the sodium hydroxide and the platinum blade on which it was found in such a way that, in the end, the flame had a lower temperature than before when it was not luminous, and yet it emitted about a third more of the heat that it had previously.

It can be that the sodium hydroxide was contained within the flame in a state of vapour or that particles removed from that body that augmented the illuminating power. Whatever the case may be, I choose, to shorten the discourse, the des-

[*] *Philosophical Transactions* for 1795, page 42.

[†] *Astronomie populaire*, Vol. II, page 94.

[‡] *Ibid.*, page 143.

[§] *Philosophical Transactions* for 1795, page 71.

[¶] *Denkschriften der Berliner Acad. Der Wiss.*, 1861, page 85.

[‖] *Comptes rendus de l'Acad. Des sciences*, Vol. XXXV, page 606 and Vol. XXXVI, page 659.

ignation of sodium hydroxide vapour.

By introducing in the place of this vapour a platinum disk in the same area of the flame that was being studied, the heat that the flame emitted became even more considerable than previously recorded. The platinum blade evidently removed from the flame even more heat than the sodium hydroxide, but it, however, radiated even more. With the blade that I was using and whose diameter was 55 mm, the radiation became nearly twice as strong then when the flame did not throw off any light. We did not observe any fundamental difference by making the blade thicker or thinner, so long as the diameter remained the same.

But if, instead of making the blade thicker, we covered it with sodium carbonate, then the radiation increased again considerably; it became fifty percent stronger than with the platinum blade without any sodium hydroxide.

The radiation would rise even more, when, apart from the platinum blade being covered with sodium hydroxide, there was also sodium hydroxide vapour in the flame, this being obtained by introducing in the lower part of the flame some sodium hydroxide on a platinum blade, in the same way as was done previously, that is to say without having the sodium hydroxide radiating over the battery.

In this case, the flame being completely filled with sodium hydroxide vapour coupled with the platinum blade covered with sodium hydroxide, the flame emitted close to three times more heat than the flame that was not luminous. Lithium hydroxide and strontium hydroxide behaved like sodium hydroxide.

These experiments demonstrate that gaseous bodies emit far less heat than solid or liquid bodies; and that, by consequence; one cannot assume that the seat of solar heat resides in a photosphere made up of gas or vapours. They also demonstrate that, and this is especially striking, that incandescent sodium hydroxide has a much greater radiative power for heat than platinum at the same temperature.

Also, they demonstrate that sodium hydroxide vapour or sodium hydroxide particles absorb only a small part of the heat emitted by incandescent solid or liquid bodies. In fact, the radiation of the solid body in the flame filled with sodium hydroxide vapour was, it is true, always smaller than the sum of the radiations of the solid body alone and of the vapour introduced alone in the non luminous flame, but the difference was small.

This manner in which incandescent liquid or vaporous sodium hydroxide behaves confirms in a striking way the views of Mr. Kirchhoff on the nature of the Sun.

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