On the anomalous extreme ultraviolet emission lines in helium–hydrogen plasma

The reported observations[1] of new emission lines in the helium–hydrogen (98–2%) plasmas have been given a simple explanation[2]. The reported observations show sharp emission lines with the energies satisfying empirical relations given by

$$E_e = 13.6n \text{ eV}, \quad \text{where } n = 1, 2, 3, 7, 9, \tag{1}$$

$$E_e = 13.6n - 21.21 \text{ eV}, \quad \text{where } n = 4, 6, 8. \tag{2}$$

Let us note that the ground state energy level of hydrogen is –13.6 eV, and this immediately hints at intriguing physics if the observations are correct. In view of the doubtful nature of 'exotic' observations in recent years in so-called cutting-edge research, we must be skeptical of this report unless independent experiments by other groups verify the observations. Assuming the correctness of the reported emission lines, let us see if Sathyamurthy[2] offers any explanation. He says that, 'if there are several H atom recombinations taking place simultaneously, under favourable circumstances, there could be emissions corresponding to integral multiples of 13.6 eV . . . ' Obviously, this does not amount to any physical interpretation, and one does not know what it means to say 'several atom recombinations'.

If these are true, is there some possible mechanism to explain the observations? Let us explore the hypothesis of photonic de Broglie waves[3] in this context. Jacobson *et al.*[3] propose that an ensemble of photons in quantum optics could be considered as a Bose condensate with de Broglie wavelength λ/N, where λ is the wavelength and N the average number of the constituent photons. To give a simple derivation, let us consider N photons with frequency ν. Then the total energy $Nh\nu$ can be used to obtain the momentum of the condensate

$$p = Nh\nu/c. \tag{3}$$

The de Broglie wavelength is

$$\lambda_b = \frac{h}{p} = \frac{\lambda}{N}. \tag{4}$$

The idea that N photons with frequency ν could behave as a single entity with frequency $N\nu$ seems strange, and in the literature counter intuitiveness of quantum mechanics is invoked. Experiments on biphoton interference and quantum entanglement have been of active areas of research, besides the geometrical phases for such photon pairs[4].

Let us assume that helium is instrumental in creating cavities where photonic condensates could form for the photons with energy 13.6 eV. One could then explain eq. (1). Following our work on geometrical phase[4] we argue that spin plays an important role in the condensate, i.e. even number of photons gives spinless state and odd number of photons gives spin-one state. The difference between eqs (1) and (2) is that in the former we have odd n (excepting 2), while in the latter (2) it is even. Here Sathyamurthy's suggestion that the photon condensate gets inelastically scattered from helium seems useful. He confines only to energy conservation; however, the angular momentum and parity selection rules have to be properly incorporated in a fuller discussion.

If the condensate mechanism is correct, one can look for its verification using the Mach–Zehnder interferometer, as proposed by Ryff and Ribeiro[4]. Here the source beam should be the emission radiation from the plasma, and the interference pattern has to be contrasted with the independent source at this frequency.

Obviously, the idea of photonic de Broglie waves is speculative, and in spite of intense work in quantum optics, the problems at fundamental level lack understanding. A radically new approach envisages photon as a composite structure and a number of photons could coalesce to create photo-balls that behave as photons[5]. This approach also deserves attention.

Another interesting idea that could be relevant here is that of effective photon hypothesis proposed by Panarella[6]. According to this hypothesis photon–photon interaction is postulated that becomes significant at high photon densities. Energy of photon depends on light intensity. Panarella had proposed experimental tests of this model in his work. It would seem that the this model could be tested in the set up of[1].

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