I understand from the organizers of this series of broadcasts that its main purpose is to give an opportunity to the 'Guest of the Evening' to speak about his latest work. Though the scientist is frequently accused of living in an ivory tower, you may be sure that he welcomes opportunities like this to explain to his colleagues and to others the problems ~~in~~ on which he ~~might be engaged~~ may be working at the moment.

We are engaged at present in organising and equipping the National Physical Laboratory of India. The main function of this Laboratory is to maintain ~~the~~ various physical standards, and to carry on research in connection with the maintenance of these standards. The function is nearly the same as that of the Bureau of Standards at Washington, or the National Physical Laboratory in Teddington, or the Reichanstadt in Berlin. In India, however, owing to certain special conditions prevailing here, the Laboratory will have to include also some research on Industrial Physics, and also some fundamental research on problems not directly connected with the maintenance of standards: because there are ~~very~~ few industries in India which maintain or can afford to maintain, large research laboratories, and again there are many branches of ~~science~~ physics for which the Research Laboratories in the country, whether in the Universities, or outside them, are not adequately equipped. ~~As,~~ Much of our time is taken at present by the organisation and adequate equipment of the ~~various~~ different sections of the National Physical Laboratory ~~of India~~. I presume the ~~organizers~~ sponsors of this series of broadcasts expect me to speak about our scientific work rather than about the problems connected with the organisation and

equipment....

equipment of the Laboratory, which I may mention in passing are sometimes even more difficult to tackle than our scientific problems. I shall confine myself in this talk to one ~~or two~~ important problem~~s~~ which we have been studying for the last few years.

More than a century ago, a great British Botanist, by name Brown, discovered a phenomenon which turned out to be epoch-making. ~~He found that~~ When fine pollon grains are suspended in water, and are suitably illuminated, and observed through a microscope, the ~~particles~~ grains are found to execute lively, random movements. The movements ~~appear to be~~ are quite spontaneous, and are also persistent. We had to wait for nearly three quarters of a century for a satisfactory explanation of ~~these spontaneous~~ ~~of the such~~ these movements. As we know now, ~~they are a reflection~~ the observed movements of ~~the~~ fine ~~suspended~~ particles suspended in a liquid are just ~~merely~~ a reflection of the spontaneous random ~~thermal~~ movements of the ~~individual~~ ultimate molecules of the ~~medium~~ liquid. In other words if ~~we had a microscope of sufficiently high resolving power through which one could watch~~ one could observe individual molecules, their movements would be ~~found to be~~ very similar to the movements of the suspended particles ~~studied~~ observed by Brown, and (even livelier) because ~~of the lightness of~~ the molecules, ~~even livelier~~ are much lighter. The higher the temperature the livelier again will be the movements. Indeed the energy of these movements is a direct measure of the temperature of the medium.

There is one important consequence of this thermal movement of the molecules in a homogenous medium. If we take a small element of volume in the medium, the number of molecules present in the volume will naturally fluctuate from the average value. The smaller the ~~relative~~ element volume.....

of volume, the more violent naturally will be these fluctuations ~~in this number. We may express this result slightly differently by saying that the density of the medium is not quite homogenous throughout~~, ~~but shows violent local fluctuations due to the random thermal movements of the molecules referred to~~, which, in honour of the discoverer, ~~the physicist calls Brownian movements.~~ Hence if we take ~~any homo-geneous~~ a medium like water, though ~~for all practical purposes~~ (for all practical purposes, i.e. on a large scale,) it may be regarded as homogenous, it will not be so on the microscopic scale, (but will on the other hand) show ~~striking~~ local inhomogeneities, which will be the more ~~pronounced~~ violent, the larger the temperature, or the greater the compressibility of the medium. When a strong beam of light is made to traverse such a medium these inhomogeneities will naturally be rendered visible by the lateral diffusion or ~~sea~~ scattering of the light by (them; and since) these inhomogeneities are highly localized, the scattering will be the greater the shorter the wavelength of the light. The beautiful blue of the sky, which we so much admire, is a direct consequence of the scattering of sun light by such local thermal fluctuations in the earth's atmosphere, ~~according to the great Lord Rayleigh~~. Had it not been for such fluctuations the sky would be pitch dark. What a drab world would it then be! The deep blue of the sea, and the delicate opalescence of glaciers and of large blocks of ice, are again due essentially to the same causes, namely thermal Brownian local fluctuations.

If the medium were a mixture say of two perfectly miscible liquids like alcohol and water the ~~local~~ thermal fluctuations ~~due to the thermal movements of the molecules~~ will naturally be more complex. If ~~the~~

the ....

we take an element of volume in the mixture the number of mole~~ne~~es of both the types, which for simplicity we may call A and B, will fluctuate from their mean valvues. Such a fluctuation, mathematically, may be split up in the following manner:

1. ~~the relative proportion between A and B the numbers of the two types present in the element of volume remains fixed, and~~ the total number of molecules in the element ~~fluctuates.~~

2. ~~The~~ total number ~~of molecules in the element of volume~~ remains ~~fixed, but the relative~~ proportions of the two types vary.

3. ~~Both~~ the total number, and ~~the~~ relative proportion ~~vary simultaneously.~~

The first term may be briefly designated as a fluctuation in density, and the second term as a fluctuation in concentration. Since these two fluctuations will be quite uncorrelated, the third term depending upon the simultaneous fluctuations of both the density and the concentration will naturally be nothing.

When a beam of light traverses such a liquid mixture, both the above types of local fluctuations namely the density fluctuation, and concentration fluctuation will separately contribute to the scattering of ~~the~~ light in its passage through the medium. Indeed under suitable conditions, e.g. when the concentration of the binary mixture is close to what the physicist calls the critical concentration for perfect misibility, the concentration part of the scattering can @@ far outweigh the density part. These consequences of thermal agitation of the molecules of a medium

are.....

are well known, and have been studied extensively both in India and abroad, ~~in India particularly by Professors Raman and Ramanathan.~~ The main point in my referring to these earlier studies is to emphasise a very important application of these well known results, namely to elucidate some very striking electrical properties of metals and alloys.

As you all know, a metal has very distinctive properties which distinguish it from a non-metal. One frequently speaks of a substance feeling cold like a metal, or hot like a metal, which imply that a metal is a good conductor of heat. We also speak of metallic electric contacts, and use the term metal frequently as a synonym for a good electrical conductor. We speak again of metallic reflection, of metallic lustre and also of the opasity of a metal, referring to its peculiar optical properties. We speak also of a metallic voice and also of being malleable or dectile like a metal, referring to its peculiar elastic properties. Chemically we speak of a metallic bond, and of intermetallic compounds to illustrate the peculiar chemical properties of metals and alloys. All these properties can ultimately be attributed to the presence in the metals of free electrons, i.e. electrons which can migrate freely from one end of the metal to the other; In other words these peculiar properties are just the properties of such a cloud of free electrons, with the positive ions which represent the rest of the atoms embedded in the cloud.

The properties of such a cloud of electrons have been studied extensively. Under ordinary conditions the wave aspect of these

electrons....

electrons is conspicious, and when the cloud is enclosed in a fine medium as any real metal or alloy, electron waves having certain discrete wavelengths can be maintained in the enclosure, just as in a stretched piano string only those notes can be maintained whose half wavelengths are equal to the length of the string or half of it or one-third of it, etc. The same thing will be true also of the vibrations in air in a closed small room, as any one who is accustomed to sing in a bath room would have realised. The air in the room resinates most readily to certain discrete frequencies characteristic of the diamensions of the enclosure.

It is of interest to enquire how the energy is partitioned among these different wavelengths that can be maintained in the enclosure. In the case of the vibrations of the air in a room it is the gravest method of fabrication that claim the largest energy, the higher hand in the case of electron waves maintained in the enclosure all the wavelengths starting from the longest and going to a certain appropriate critical value are equally intense, each wavelength actually claiming just two electrons, one with a right-handed spin and the other with a left handed spin. In other words, all permitted wavelengths in the enclosure longer than a certain critical value will be maintained in the medium, and none shorter than this critical wavelength.

If the metal were perfectly homogenous, these electrons can move about completely freely from one end of the metal to the other, and hence the medium will be an ideal conductor, having no

electrical.....

If the metal were perfectly homogeneous, these electrons can move about completely freely from one end of the ~~medium~~ metal to the other, and ~~the metal~~ hence ~~it~~ the medium will be an ideal conductor, ~~so~~ having no electrical resistance at all. But actually owing to the thermal fluctuations which I referred to ~~the and the~~ there will be local inhomogeneities which will scatter the electrons in the same manner in which ~~the~~ ~~elect~~ ~~the~~ such homogeneities in a transparent medium scatter light. The ~~resistance~~ resultance a finite resistance, which will be the greater the large such fluctuations.

~~In a p~~ All calculations of electrical resistance therefore reduce to a calculation of the attenuation of the electron waves, as they pass through the metal, ~~and~~ the attenuation being ~~drivin~~ due to the scattering of these waves by the thermally agitated atoms, i.e. by the local fluctuations in density.

In an alloy, ~~the~~ naturally ~~owing to~~ the fluctuations in concentration also will contribute to the scattering, and hence to the resistance, the contribution ~~to~~ from such fluctuations of concentration, under certain conditions, being ~~the~~ much more predominant than the fluctuations in density. The enormous increase in resistance due to alloying ~~previously~~ noticed by earlier workers, ~~remains~~ receives a natural explanation on this basis, as also many other electrical properties.

This is a fine illustration of how the mathematical technique developed for the study of one physical phenomenon ~~e.g. like~~ light-scattering in this case, helps to elucidate

~~quite different~~

problems in quite other branches of physics, and how physics grows by such intensive cross fertilizations.

This conference wishes to emphasise the need for training of theoretical physicists in the country, and since such a training ~~will~~ can ~~best~~ ~~appropriately and adequately~~ be given by the Universities, ~~and~~ ~~will fit~~ and quite approp. the conf. recom. to the Univs the institution of graduate and post-g. courses in theor. physics

The conf. further recom- the following syllabus as ~~covering~~ ~~for~~ providing an adeq

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