IMO PRIZE TO PROF. P.R. PISHAROTY--
FELICITATION AT PRL
09 MARCH 1990

Friends,

It is indeed a moment of great joy and pride for all of us to see that Prof. Pisharoty has been honoured with this highly prestigious IMO Award of the World Meteorological Organization. This is, of course, a unique distinction for Prof. Pisharoty who now formally joins the list of great names in Meteorology, such as Rossby, Jule Chamey,
and, of course, our own Prof. K.R. Ramanathan to whom this distinction came in 1961. I say formally, because we knew all along that he always belonged to this class of highly distinguished Meteorologists. The award only vindicates our conviction.

On behalf of all of us assembled here and on my own personal behalf, I would like to convey our heartiest congratulations to you, Prof. Pisharoty and also to you, Mrs. Pisharoty, for being accorded this unique distinction. As wives of most scientists would know, but may or may not complain, how hard it is on them to bear the loneliness resulting from their husbands' frequent trips away from home. I do believe, however, that they do share the joys of their husbands' achievements because they really have been an integral part of the efforts--a life long effort--whenever such distinctions arrive.

We salute you, Mrs. Pisharoty, for being such a true companion to Prof. Pisharoty and to see him to this point of achievement and honour.

It is, of course, also a matter of unique honour to PRL that one of our most reverred colleagues has been so honoured. I think it is worth pointing out that only two IMO awards which have come to India have come to PRL only because these distinguished scientists belonged to PRL.

I have mentioned earlier about Prof. Pisharoty joining the class of other distinguished meteorologists. But, in fact, that does not do full justice to Prof. Pisharoty. We know that he is much more than just a member of that select class. He is a remarkable young man, remarkable because at 81, he is indeed young--young in spirit and enthusiasm.

If you are feeling down and low in spirits, you walk into his room. A smiling and cheerful Prof. Pisharoty welcomes you and you bounce back to your high spirits. He has thus been a source of great strength to all of us.

I want to give some examples of his youthful enthusiasm and his commitment to science. After our return from Delhi after the award presentation ceremony, I found a write-up from him on

"Flapping of Flags in Wind"

where he has presented a mathematical analysis of the phenomena of flag flapping. He claims that the analysis is a repetition of Rayleigh's analysis in the Proceedings of the London Mathematical Society X, pp.4-13 (1879). May be it is. But it is not the important thing. The important thing is that Prof. Pisharoty at 81 has felt the urge to learn about the flapping of the flag and put it down on paper to tell others about it. But I must, however, add that the write-up even if it is based on Lord Rayleigh's analysis, has a distinct Pisharotian touch. (Of course, this one does not have a sloka in it).

I have, of course, over the last three years or so received many write-ups from Prof. Pisharoty on a variety of topics, ranging from weather forecasting to science policies and problems of education and role of motivation in science, to human relationship and so on. They are full of wisdom. And I have collected them and kept them safely as my treasured possession.

Now I would like to say something which is important to all of us. Prof. Pisharoty belongs to a generation which grew up in an ambience that was charged with the fervour of the struggle for independence, an ambience charged with an air of duty before self, a sense of commitment and dedication to the cause of learning and the cause of nation building. Never did this generation ask for what they should get from their organization or their country. They only knew how best they could give. They accepted what they got, in all their humulity, not as something in return, but something that just happened and taking the opportunities of their higher position so obtained more as bigger responsibilities that they must discharge and live upto. This is in the highest traditions of the Indian thought and ethos.

I often feel we are so lucky to have Prof. Pisharoty amongst us--a store-house of wisdom and a tower of strength, an epitome of the sense of duty, responsibility and commitment - a commitment to a sense of values which are sadly disappearing very fast.

There is now a rush towards quick success in all spheres, cutting corners, beating your rivals and competitors, to reach a goal. Learning is a long, hard and difficult process. But at the end of it lies not a goal in the form of success in ill-defined term, but a pleasure of knowledge, a pleasure of its own. The secret of such a pleasure, I believe, has been revealed to men like Prof. Pisharoty. That is why he always looks so happy, so contended and at peace with himself and his surroundings.

I am also sure, he also feels a sense of contentment for having done his duty to his fullest extent.

We are indeed all delighted to be with Prof. and Mrs. Pisharoty today to share their joys and to rejoice together with them on this day for the distinction they have got and the distinction that they have brought to PRL.

We again congratulate them both and hope and wish they would continue to be with us for many more years to guide us as our guru and as our friend.

.....

Prof R.K. Varma
regards,
Pisharoty

FLAPPING OF FLAGS IN WIND

(P.R.Pisharoty)
PRL

Flag hoisting ceremonies have become common in India. Defence Service Offices do it every day. It was common in Ancient days also.

All of us have observed that a flag does not flap when the wind is weak. On the other hand steady waves propagate along the length of the flag when the wind is relatively strong.

Lord Rayleigh has discussed this phenomenon as a problem in fluid motion in a paper published in the Proceedings of the London Mathematical Society X-pp 4-13, 1879. It is felt that it has some relevance to the dissipation of energy, when conditions are otherwise favourable for the development of a tropical disturbance - a monsoon depression or a tropical cyclone.

In the following, Rayleigh's analysis is almost repeated.

Let us suppose that there is a plane surface of separation within a fluid, on the two sides of which the fluid velocities are parallel to the surface but different in magnitude. Let us denote the surface of separation by $Z = 0$, and the velocities either side of it by V_1 and V_2 respectively, their direction being parallel to the axis of X. In the absence of friction, the motion consequent upon any deformation of the surface of separation is deterministic. By Fourieri Theorem, any displacement in two dimensions can be resolved into component displacements of the undulating type, and the effect of any undulatory displacement can be considered independently of others.

We might therefore take the initial equation of the surface of separation as

$$h = H \cos k x$$

in which h denotes the elevation at any point, λ is the wavelength of the disturbance and $k = 2\pi/\lambda$. But in almost all such cases, it is more convenient to use complex numbers, from which the imaginary parts are finally rejected. We will therefore assume

$$h = He^{int}e^{ikx} \quad \ldots\ldots (1)$$

The principal question we will have to consider is the dependence of n on the wavelength λ , or on k.

For the velocity potential on the positive side of Z, we may take

$$\phi_1 = Ae^{int}e^{ikx}e^{-kz} + V_1 x \quad \ldots\ldots (2)$$

where A has to be determined by equating the velocity normal to Z = 0, i.e. the surface of separation with that obtained from the following equation, giving the vertical upward velocity at Z = 0. We assume that the positive direction of Z is downwards.

$$-\frac{\partial\phi_1}{\partial z}(z=0) = k e^{int} e^{ikx}$$
$$= \frac{dh}{dt} + V_1\frac{dh}{dx}$$
$$= (in + ikV_1) H e^{int} e^{ikx} \quad \ldots (3)$$

Whence

$$A = ik^{-1}(n + kV_1) H \quad \ldots (4)$$

So that

$$\phi_1 = ik^{-1}(n + kV_1) H e^{int} e^{ikx} e^{-kz} + V_1 x. \quad \ldots (5)$$

Similarly, for the fluid on the negative side

$$\phi_2 = -ik^{-1}(n + kV_2) H e^{int} e^{ikx} e^{kz} + V_2 x \quad \ldots (6)$$

The other condition to be satisfied is the equality of pressure on both sides of the surface of separation.

If σ denotes the density, the hydro-dynamic equation of pressure for the first fluid is

$$p_1 = C_1 - \sigma_1\frac{d\phi}{dt} - \frac{1}{2}\sigma_1 U_1^2 \quad \ldots (7)$$

and approximately, when $Z = 0$,

$$\frac{1}{2}U_1^2 = \frac{1}{2}\left(\frac{d\phi_1}{dx}\right)^2 + \frac{1}{2}\left(\frac{d\phi_1}{dz}\right)^2$$
$$= \frac{1}{2}V_1^2 - V_1(n + kV_1) H e^{int} e^{ikx} \quad \ldots (8)$$

Similarly

$$p_2 = C_2 - \sigma_2\left(\frac{d\phi_2}{dt}\right) - \frac{1}{2}\sigma_2 V_2^2 \qquad \ldots (9)$$

And approximately, when Z = 0

$$\frac{1}{2}U_2^2 = \frac{1}{2}\left(\frac{d\phi_2}{dx}\right)^2 + \frac{1}{2}\left(\frac{d\phi_2}{dz}\right)^2$$
$$= \frac{1}{2}V_2^2 + V_2(n+kV_2)He^{int}e^{ikx} \qquad \ldots (10)$$

Since $p_1 = p_2$,

$$\sigma_1(n+kV_1)^2 + \sigma_2(n+kV_2)^2 = 0 \qquad \ldots (11)$$

This equation determines the relation between n and k.

Usually this equation is dealt with when $V_1 \neq V_2$, and or $\sigma_1 \neq \sigma_2$. When $V_1 \neq V_2$ but $\sigma_1 = \sigma_2$ we have the billow waves in the sky, showing themselves as billow clouds - usually stratocumulus or altocumulus streets.

When $V_1 = V_2$ but $\sigma_1 \neq \sigma_2$, eg when fresh water forms a layer on sea salt-water, we have waves forming on the interface, not visible on the sea surface. When ships float on such a composite sea, they do not move even under full engine power. This is usually experienced in Norwegian waters and they call it dead water. The power is taken away by the underwater waves. This true explanation of "dead water" of the Norwegian seas was given by Nansen in 1906

In the flapping of flags, we are concerned with the situation, when $\sigma_1 = \sigma_2$ and $V_1 = V_2$. And then the relation reduces to

$$(n + kV)^2 = 0$$

$n = -kV$ is a double root. The solution is of the form

$$h = (A + Bt)\, e^{ik(x - Vt)}$$

We had put $h = H \cos kx$ as the initial state at $t = 0$. With out any loss of generality, it can be put as

$$h = \cos kx, \text{ at } t = 0.$$

which means that $A = 1$.

Also $$\frac{dh}{dt} = 0 \quad \text{at} \quad t = 0$$

ie $$\frac{dh}{dt} = (A + Bt)(-ikV)\, e^{ik(x - Vt)} + B\, e^{ik(x - Vt)}$$
$$= 0.$$

Hence $$h = e^{ik(x - Vt)} + ikVt\, e^{ik(x - Vt)}$$

Taking the real part of the solution:

$$h = \cos k(x - Vt) - kVt \sin k(x - Vt)$$
$$= \cos k(Vt - x) + kVt \sin k(Vt - x)$$

The peculiarity of this case, which I would like, to emphasise, is that previous to the sinusoidal displacement, there is no real surface of separation.

When there is a stretched flag, the surface of the flag merely makes the oscillations in the fluid flow visible. The equation shows how the perturbations <u>increase in the amplitude of the oscillations with time</u> in proportion with the wind.

cf the term

$$kVt \sin k(Vt - x)$$

When there is a stretched flag, the increase in the amplitude with time leads to a <u>flapping</u> of the flag.

When t is small, such that $Vt\, 2\pi/\lambda$ is small, it is a Cosine Wave propagating with a velocity V and a period $\tau = \lambda/V$. However superposed on this is an amplifying Sine Wave. The rate of amplification is high. In the period τ ie λ/V , the amplification factor is 2π almost six times. The greater the wind speed, the greater the rate of amplitude or faster the state of flapping.

It is felt that this has a significance in the non-development of tropical disturbances, even when the thermo-dynamic conditions are favourable.

Greater amplification of such a body wave means a greater amount of kinetic energy and potential energy taken up by the waves. If the wavelength is 200 km, and the wind speed 20 metres/sec (40 knots)

$$\tau = \frac{200 \times 10^3}{20} = 10^4 \text{ sec}$$

$$\approx 3 \text{ hours.}$$

A significant amount of energy of the system will be propagated out of the area in 2-3 hours, and would continue. The weather system would not develop.

...