Discussion on P&G 13.2, 20-26 (2002),

i.e. about coexistence of 2 temperatures in mixing…

P. Evesque

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Abstract :
Testimony #1 was produced to "la Cour administrative d'Appel" in Paris; so the following correspondence is no more private but open to anybody and can be used by anybody refereeing to it.

Pacs # : 5.40 ; 45.70 ; 62.20 ; 83.70.Fn

Paper [1] was sent for peer reviewing and publication in Phys. Rev. Lett.. It was rejected after the process. As the peer reviewing is transferred from private to public correspondence through the action to the CAZA court, this allows its publication. Here are the discussions obtained through the peer review. This may help other scientist to get further information.

Of course, I am ready to answer other questions. And I did not consider the objections as important scientifically. So the paper was published in Poudres & Grains, and I am still confident on what it concludes.

I consider Phys Rev Lett as partly using/(subject to) lobbying

References:

[1] P. Evesque, Are Temperature and other Thermodynamics Variables efficient Concepts for describing Granular Gases and/or Flows **?**, *Poudres & Grains* **13** (2), 20-26 (Mars-Avril 2002) ISSN 1257-3957,

[2] http://defense-pierre-evesque.over-blog.com/; [3bis] 2ème réponse au CNRS (27/4/2016) via la Cour Administrative d'Appel de Paris (http://www.poudres-et-grains.eu/datas/suite_affaire_2/3rr-mem-22.4.16-CAA.pdf) which makes public the private peer-reviewing correspondence.

[3] http://poudres-et-grains.eu/datas/temoignages/Temoig-1_editionsCL-23-6-11.pdf , pp. 124-134

Article PRL_LSK813 refusé en Août 2002 par Phys Rev Lett : "Comment on "Coexistence of two granular temperatures in binary vibrofluidized beds" by Pierre Evesque

Je n'ai pas accepté considérer les reproches de Phys Rev Lett. Il a été publié sans réel amendemant dans Poudres & Grains en Avril 2002 (P. Evesque, Poudres & Grains 13 (2), 20-26 (2002), " Are Temperature and other Thermodynamics Variables efficient Concepts for describing Granular Gases and/or Flows ?")

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P.Evesque / submitted to PRL - 1 -

Comment on:

"Coexistence of Two Granular Temperatures in Binary Vibrofluidized Beds" **by R.D. Widman & D.J. Parker** [1] [*Phys. Rev. Lett.* **88**, 64301 (2002)]

P. Evesque

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Abstract:

Using two particle species differing only by their mass, we demonstrate that a vibrator acts rather as a "velostat" instead of a thermostat, which means that it imposes a typical speed distribution with a typical width $\underline{V}$ to an ensemble of grains instead of imposing a temperature $T=m\underline{V}^2/2$. This allows to understand the results described in the paper quoted in the title and to predict the coexistence of two temperatures T_1 and T_2, one for each species. Be $m_1>m_2$, this approach finds also that $T_1>T_2$, and the smaller the concentration c_1 the smaller T_1 and the larger T_2. This cast a serious doubt on the interest of applying the temperature concept to granular dissipative gases. We further describe some other consequences.

Pacs # : 05.40.-a ; 05.70.-a ; ~~45.70-n~~ ; 89.75.-k

voir à la fin du dossier PRL

P. Evesque, Testimony #1, CL MSSMat on 23 June 2011 p.129/238

This paper is similar to the one published by Poudres & Grains (P&G 13.2, 20-26 (2002))

Paper [1] describes a very nice experimental work, which leads to puzzling physics; for instance, it demonstrates unambiguously that the dynamics of a granular medium made of two kinds of grains and submitted to a vertical vibration is characterised by two different temperatures in general, one for each kind of grain; and that these temperatures depend on the proportion of each particle. This may surprise at first sight because it seems to be in contradiction with classic thermodynamics. However, this comment suggests the basis for some possible simple understanding of this phenomenon. The main concept underlying this approach is the fact that a vibrator acts as a "velostat" and not a thermostat, which means that it imposes mainly the mean particle velocity so that the kinetic energy it imposes depends on the particle mass. In order to prove this point , we start and consider the case of a gas made of a single kind of particles; we find its typical-temperature as a function of the particle mass, keeping constant all the other parameters; then we investigate the mixing of two species differing only by their masses; at last we turn to the case of particles having different masses and different diameters, in the granular gas regime. This will allow to conclude that thermodynamics quantities and concepts, such as temperatures,…, might be more difficult to transpose to the physics of granular gas and granular flow than it was thought originally [2]; this difficulty would come from both (i) the difficulty of building thermostats and other thermodynamics tools, and (ii) from the local dissipation which makes the granular gas non homogeneous and granular gas quantities non conservative .

So, let us start demonstrating that a vibrator acts as a "velostat". We consider first the case of a granular gas made of a single kind of particles of diameter d and mass m submitted to a vertical sinusoidal vibration (frequency $f=\omega/[2\pi]$, amplitude a) imposed by a piston (mass M, horizontal size L). Be also nd the thickness of the a uniform layer when a=0; so, n stands for the mean coverage ratio, *i.e.* n is the mean number of bead layers covering the piston at rest; and the total number of particles N is given by $N=\alpha n(L/d)^2$, where $\alpha \cong 1$ is a coefficient of normalisation which takes into account the density of arrangement of the regular lattice used for normalisation. We assume (i) that L>>d and $L>>d/\sqrt{n}$, so that lateral wall effects become negligible and (ii) that $M/L^2 >> m/d^2$ and M/L^2

$>>n\, m/d^2$ so that the piston mass can be considered as infinite for collision rules. We assume also that bead-bead and bead-piston collisions are both governed by the same restitution coefficient ε and that we can neglect the air effect. Let us also neglect particle rotation, stating for instance that the rotation kinetic energy behaves as the mean translation kinetic energy.

The equality between inertial mass and gravity mass imposes that the mass m of the particles does not play any part in determining the particle -trajectories and -speeds because it intervenes neither in the free-flight dynamics nor in the collision characteristics, as far as the restitution coefficient ε remains independent of the speed V. This leads to predict that two sets of identical particles having the same diameter and the same coverage ratio n and submitted to the same vibration excitation will vibrate similarly even if the two particles have different masses m_1 and m_2, the restitution coefficient being assumed the same, *i.e.* $\varepsilon_1=\varepsilon_2$. It means that these particles will get the same typical speed $\underline{V}$, independently of m. So, $\underline{V}=\underline{V}_1=\underline{V}_2$. Of course, $\underline{V}$ depends on the other experimental parameters which are a, ω, ε, n, g, d; in particular, one expects that the larger a and/or ω the larger the grain speed so that dimensional analysis leads writing:

$$\underline{V}= a\omega\, f\{\varepsilon, n, d/a, gd/(a\omega)^2\} \qquad (1)$$

where f is a function of 4 dimensionless parameters. Indeed, as m/m=1 and m/M=0 are both independent of m, dimension analysis confirms also that **Eq. (1) is independent of m**. Furthermore, as the "granular temperature" T is defined as $T=\langle mV^2/2\rangle= m\underline{V}^2/2$, **this demonstrates that a vibrator is a "velostat" instead of a thermostat**, which means that it imposes a speed and not a temperature (or a mean kinetic energy). Indeed if we consider two granular gases differing only by the mass m_1 & m_2 of their grains, so that $m_1>m_2$, but $d_1=d_2$, $n_1=n_2$, $\varepsilon_1=\varepsilon_2$, $a_1=a_2$ and $\omega_1=\omega_2$, Eq. (1) imposes $\underline{V}_1=\underline{V}_2$ so that their temperatures T_1 & T_2 are different, their ratio being $T_1/T_2=m_1/m_2$. But the heights H_1 and H_2 of their cloud are equal, *i.e.* $H_1=H_2$, since $\underline{V}_1=\underline{V}_2$.

Let us now investigate the mixing of these two gases in proportion c_1 & c_2, $c_1+c_2=1$, keeping $n=n_1c_1+n_2c_2$ constant: relabelling $T_{1,o}$ & $T_{2,o}$ their temperatures when they are separated ($T_{1,o}$

$> T_{2,o}$) & ($V_{1,o} = V_{2,o}$), and as mixing shall smoothen the temperature difference, one expects then that mixing (i) lets $T_1>T_2$, but that (ii) $T_1-T_2< T_{1,o}-T_{2,o}$, so that it heats up the lighter particles from $T_{2,o}$ to $T_2=T_{2,o}+\Delta T_2$ and cools down the heavier ones from $T_{1,o}$ to $T_1=T_{1,o}-\Delta T_1$ in such a way (i) that $T_1 - T_2 < [T_{1,o}-T_{2,o}]$ and (ii) that the larger c_2 the larger ΔT_1, while the smaller c_1 the larger ΔT_2 . In particular, this analysis does not conclude to the necessity of a thermodynamics equilibrium between the two species so that one shall accept that $T_1\neq T_2$ in general. Furthermore as the two mean speeds are now different $\underline{V}_1\neq\underline{V}_2$, one expects that H_1 and H_2 be different too, leading probably to predict the existence of some spatio-temporal segregation.

Let us now compare the characteristics of two granular gases of identical particles under the same excitation (a,ω); as we want to investigate the gaseous case, we limit to small value of n and rather large value of the acceleration $a\omega^2>>g$. We consider two granular gases with the same number of layers at rest, so that $n_1=n_2=1$. Be (m_1 ,d_1) & (m_2,d_2) the particle- (mass , size) of each gas respectively. Eq. (1) predicts that their speed $\underline{V}_1$ and $\underline{V}_2$ can be different, due to the difference between d_1 and d_2. However, let us assume that we are investigating the case of a granular gas for which the cloud height H shall be large, *i.e.* H>>d, H>>a. Indeed in this limit, one expects that confinement is due to g, so that H scales as $\underline{V}^2/g$ and that $\underline{V}$ scales as aω, for a fixed set (n, d, m). This imposes that d/a and $gd/(a^2\omega^2)$ do not play some important part. In turn this assumes that $a\omega^2>>g$.

At this stage, it is worth noting by passing that the mean free path l_c is given by $l_c=(L^2H)/[N\pi d^2]$ so that it scales as H/n and is independent of d. Furthermore, when n>1, one expects the gas to be not homogeneous along the vertical so that l_c increases with the height in the cloud; this is due to both the action of local collision dissipation and to the mean confining pressure which decreases when the upper layer is approached.

According to the previous approximation, as far as n remains constant, one shall expect that mixing of two granular gases made of particles of different sizes shall behave approximately as the mixing of two granular gases of identical particles having different masses. So, one can compare this prediction to the experimental results of paper [1]; indeed, in this paper the ratio of the two particle masses m_1/m_2 is given by $m_1/m_2=(d_1/d_2)^3=(5/4)^3=1.95$, and the 3 proportions (c_1,c_2) studied preserve the constancy of n, since the bead number (N_1,N_2) satisfy $(N_1d_1^2+N_2d_2^2)=(700d_1^2)=(1080d_2^2)= \alpha L^2 =$ constant. So the above approach predicts that T_2 shall increase continuously from T_{2o} and T_1 shall decrease continuously from 1.95 T_{2o} to some limit when increasing c_2 from 0 to 1; it predicts also that $T_1/T_2<T_{1,0}/T_{2,0}=1.95$. Indeed, Fig. 3 of ref. [1] displays these behaviours: the larger c_2 the cooler T_1 and the hotter T_2 (even if T_2 does not vary so much, *i.e.* $T_2=2.6 \cdot 10^{-5}$ J); this is in agreement with the previous approach. Furthermore as T_2 remains constant about, rather independent of c_2, one can assume that $T_{2,o}\cong 25 \cdot 10^{-6}\text{J} \cong T_2$, and predict $T_{1,o}=1.95\ T_{2,o}\cong 49 \cdot 10^{-6}$J . This is compatible with the observed data of Fig. 3.

So our approach seems to be in better agreement than the values reported in Table 1 of ref. [1] and cast a serious doubt on the validity of the theories which have allowed to establish this Table.

On the other hand, our approach is not able to predict the constancy of T_2 when c_2 increases. This demonstrates that much work has to be performed in this stimulating domain of the granular gases. Our approach predicts the value for T_{1o} & T_{2o}; it is a pity the experimental results are not reported in [1].

If this approach is valid, the scaling shall be valid in the small g limit. So it shall be valid for g=0 too, which means for weightlessness condition. Taking $T_{2,o}\cong 25 \cdot 10^{-6}\text{J} \cong T_2$, and density $\rho=8 \cdot 10^3$ kg/m^3, one finds the typical speed $\underline{V}_{2,o}=\underline{V}_{1,o}=[3T_{2,o}/(16\pi\rho d^3)]^{1/2}=0.216m/s=0.413$ aω. This value 0.413 for f is not far from the value 0.25 which has been found approximately experimentally for granular gas of bronze beads with n=1 in weightlessness condition [3, 4] in a vibrating cubic container. The difference can be explained by the difference of restitution coefficient and a slight change in the value of n.

At last, the main conclusion of this work will be brought by the following remark: this simple approach demonstrates that granular gases violate the classic laws of the kinetic theory of gas: this is because it is not easy to build a good "granular-medium" thermostat so that the temperature of a mixture is not a well defined quantity. A "velostat" seems to be an easier tool when particles are identical, but the concept fails at once when the granular gas is made of different particles of different masses. So the real question is: (1) Are classic thermodynamics concepts and variables efficient to describe granular gases? Or do these quantities so inhomogeneously distributed that they become meaningless? (2) How strongly local dissipation does perturb the problem make it inhomogeneous?

Acknowledgements: CNES is thanked for partial funding.

References:

[1] R.D. Widman & D.J. Parker, *Phys. Rev. Lett.* **88**, 64301 (2002)

[2] P.K. Haff, *J. Fluid Mech.* 134, 401, (1983)

[3] E. Falcon, R. Wunenburger, P. Evesque, S. Fauve, C. Chabot, Y. Garrabos & D. Beysens, *Phys. Rev. Lett.* **83**, 440-443, (1999)

[4] P. Evesque, D. Beysens & Y. Garrabos, *J. de Physique IV France* **11**, Pr6-49 to 56 (2001)

The reviewing by PRL leads to the rejection of the paper as shown below:

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Re: LSK813
Comment on "Coexistence of two granular temperatures in binary=vibrofluidized beds"
by Pierre Evesque

Dr. Pierre Evesque
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Dear Dr. Evesque:

We received your Comment on the Letter by Wildman et al. Although we make no judgement of its scientific value, it does not appear to satisfy our criteria for Comments; consequently we are not able to consider it for publication. A description is enclosed.

Basically the burden of a Comment should be to correct or criticize in a collegial way points which are central to the Letter. Extensions and clarifications do not qualify, by definition, for a Comment. In general such work could appear as a regular Letter (if criteria are met) or as an article elsewhere.

Physical Review might publish a suitable "Comment" on a PRL as a Brief Report. I cannot speak for those Editors but to be considered one probably need only provide a manuscript styled as a Brief Report rather than as a formal Comment on a Letter in PRL.

If you feel we have misjudged your Comment, further consideration can be

vesque, Testimony #1, CL MSSMat on 23 June 2011 p.125/238 given to a Comment which you feel meets our criteria. Please explain. Consider whether the text of your Comment needs modification to make its basic point clear in the opening paragraphs.

Yours sincerely,

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PHYSICAL REVIEW LETTERS

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Re: LSK813EJ
Why the granular temperature of binary vibrofluidized beds is dependent on grain and concentration
by Pierre Evesque

Dr. Pierre Evesque
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Dear Dr. Evesque:

The above manuscript has been reviewed by one of our referees. Comments from the report are enclosed.

The Physical Review editors wish to accept only papers that, in addition to being scientifically sound, are important to the field and significantly advance physics. The enclosed comments suggest that these acceptance criteria are not met.

Yours sincerely,

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Report of the Referee -- LSK813EJ/Evesque

This article discusses the issue of energy equipartition in vibrated granular gases. It argues that in general, one should not expect equal temperatures for different types of particles. While this conclusion is correct, I found this article to be confusing. The article is poorly written. Notations are not properly defined, and the arguments are not explained in a clear fashion. Many relevant works are not referred to.

The issue of energy equipartition discussed deserves a comment. Because granular gases are highly dissipative, there is no reason to expect that velocity fluctuations (typically called "granular temperature") of two different components of a binary mixtures are the same. However, this is refereed to as "puzzling Physics", or, "contradiction of thermodynamics". I am not aware of published works suggesting that "granular temperatures" of components of a mixture should be the same. The skim reference list does not include references to such claims.

In its current form, the article is a cross between a comment on the above misconception, a comment on the letter of Widman and Parker, and new research. Although the discussion may be valuable, the presentation makes it of little use for researchers in this field. A much more comprehensive presentation, where the ideas discussed are fully developed, including to generic new predictions, that can be tested against theory, experiment, or simulations, is recommended. In its current form, the article does not contain sufficient new results, and

therefore, is not suitable for publication.
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PHYSICAL REVIEW E

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In order to improve the quality of papers published in PRE, we are sending the following note to referees. Because the message affects authors equally, we enclose this copy for your information.

The Editors

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We appreciate your efforts and thank you for your help. Your contribution as a conscientious referee to maintain high standards will benefit not only the journal but the scientific community as a whole.

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