唐孝威 等著

物理·生理·心理·病理

ZHEJIANG UNIVERSITY PRESS
浙江大学出版社

唐孝威 等著

物理·生理·心理·病理

ZHEJIANG UNIVERSITY PRESS
浙江大学出版社

图书在版编目（CIP）数据

物理·生理·心理·病理/唐孝威等著．—杭州：浙江大学出版社，2009. 3

ISBN 978-7-308-06548-1

Ⅰ. 物…　Ⅱ. 唐…　Ⅲ. ①物理学-研究②生理学-研究③心理学-研究④病理学-研究　Ⅳ. O4　Q4　B84　R36

中国版本图书馆 CIP 数据核字（2009）第 011279 号

物理·生理·心理·病理
唐孝威　等著

策划编辑　王志毅
责任编辑　钱济平
装帧设计　王小阳
出版发行　浙江大学出版社
（杭州天目山路 148 号　邮政编码 310028）
（E-mail：zupress@mail. hz. zj. cn）
（网址：http：//www. zjupress. com）
排　　版　北京京鲁创业科贸有限公司
印　　刷　杭州杭新印务有限公司
开　　本　640mm×960mm　1/16
印　　张　28. 75
字　　数　347 千字
版 印 次　2009 年 4 月第 1 版　2009 年 4 月第 1 次印刷
书　　号　ISBN 978-7-308-06548-1
定　　价　48. 00 元

前　言

物理学、生理学、心理学和病理学是自然科学的重要学科。物理学研究物理世界的规律及其应用；生理学研究生命活动的规律及其应用；心理学研究心理和行为的规律及其应用；病理学研究疾病发生的规律及其预防与治疗。这些学科研究的内容非常广泛。本书介绍唐孝威院士与合作者在这些学科领域中对若干问题进行的研究工作。

唐孝威先生是核与粒子物理学家，又是生物与医学物理学家和脑与认知科学家。他早年在原子核研究单位，参与我国核探测器的创业。他长期在国防基地从事我国国防科研工作，并解决一系列关键技术问题。此后他领导中国实验组，参加高能物理国际合作实验，在高能物理基础研究中作出重要贡献。其后他致力于多学科的交叉研究，包括物理学、生物学、医学、脑科学、心理学、认知科学间的交叉研究，为开拓我国医学物理学、脑功能影像学和神经信息学等学科领域作过长期不懈的努力。

唐先生在2001年调到浙江大学从事教学和科研工作。他和浙江大学及国内有关单位的合作者，在物理学、生理学、心理学和病理学等学科领域中，选择若干问题进行实验研究和理论研究，如：物理学中的颗粒物质问题，生理学中的脑功能问题，心理学中的认知过程问题，和病理学中的老年性痴呆症等问题。

2004年广西科学技术出版社出版了《粒子·空间·细胞·大脑》一书，2008年浙江大学出版社出版了《脑与心智》一书。这两本书曾

分别选编过唐先生和合作者的部分科学论文。前者选编他在2001年前在粒子、空间、细胞、大脑等领域中发表的部分科学论文，后者选编他近年在脑与心智领域中发表的部分科学论文。

本书是从唐先生近年与合作者在物理学、生理学、心理学和病理学方面在学术刊物上发表的150多篇科学论文中，选择有代表性的、以上两本书中没有收录过的部分科学论文汇编而成。本书所选论文（除少数外）都是唐先生在2001年到浙江大学后发表的。读者可以从中了解唐先生到浙江大学后和合作者进行科学研究的情况，并且也可以得到有关领域的一些科学知识。

本书包括物理研究、生理研究、心理研究和病理研究四部分。各部分分别有简短的说明，在各部分中同类工作的论文按发表时间先后排列。各篇论文都注明全部作者姓名、作者单位、发表刊物及发表时间。

最后，引用《唐孝威院士的科研历程》一文作为本书附录。

目　　录

第一部分　物理研究

第二部分 生理研究

第三部分 心理研究

第四部分　病理研究

第一部分 物理研究

说 明

本书选的物理研究论文主要包括两方面工作，一是颗粒物质实验，二是飞秒激光脉冲产生等离子体射线实验。

21 世纪初，唐先生在浙江大学物理系和同事们建立颗粒物质实验室，进行颗粒物质的实验研究。

2003 年发表的论文报告了传送带上颗粒流的临界现象（本书 3 页至 10 页）。2004 年发表的论文报告了边界条件对二维斜面颗粒流颗粒分布的影响（本书 11 页至 20 页）。2004 年发表的论文报告了二维颗粒流通道宽度效应的分子动力学模拟（本书 21 页至.31 页）。2005 年发表的论文报告了通道宽度对二维粗糙边界斜面颗粒流的影响（本书 32 页至 39 页）。2005 年发表的论文报告了二维斜面粗糙边界附近颗粒流量密度分布（本书 40 页至 47 页）。2006 年发表的论文报告了二维粗糙边界斜面颗粒流横向密度分布的双峰结构（本书 48 页至 56 页）。

20 世纪 90 年代后期，唐先生和中科院高能物理所的同事参加中科院物理所光学物理实验室飞秒激光脉冲产生等离子体的实验，着重进行等离子体发射射线的测量。

1998 年发表的论文报告了飞秒激光脉冲与固体靶相互作用的等离子体产生的 γ 射线（本书 57 页至 66 页）。1998 年发表的论文报告了预脉冲对 5mJ 能量飞秒激光产生的 γ 射线辐射的影响（本书 67 页至 75 页）。2001 年发表的论文报告了偏振态对飞秒激光等离子体相互作用中

超热电子产生的影响（本书 76 页至 84 页）。2001 年发表的论文报告了激光偏振态对飞秒激光等离子体产生的快电子喷射的效应（本书 85 页至 95 页）。

此外，唐先生还和合作者进行纳结构物性的分子动力学模拟。2007 年发表的论文报道了碳纳米管长度对水渗透率的影响（本书 96 页至 106 页）。

Critical Phenomenon of Granular Flow on a Conveyor Belt*

Bao Desong**1 Zhang Xunsheng[1] Xu Guanglei[1]
Pan Zhengquan[1] Tang Xiaowei[1] Lu Kunquan[2]

1. Department of Physics, Zhejiang University, Hangzhou, 310027, China;
2. Institute of Physics, Chinese Academy of Sciences, Beijing, 100080, China

Abstract The relationship between thegranular wafer movement on a two-dimensional conveyor belt and the size of the exit together with the velocity of the conveyor belt has been studied in the experiment. The result shows that there is a critical speed v, for the granular flow when the exit width d is fixed (where $d=R/D$, D being the diameter of a granular wafers). When $v<v_c$, the outflow rate Q increases linearly with the speed v and the flow rate $Q=\rho vR$. The turning point of the $Q-v$ curve occurs at the speed v_c. The critical speed v_c, is dependent on the exit width d. When $v>v_c$, the flow rate Q is described as $Q=C\rho v^{\beta}\ (d-k)^{3/2}$. These are the effects of the interaction among the granular wafers and the change of the states of the granular flow due to the changing of the speed or the exit width d.

Introduction

Granular matter exists extensively in nature and in our daily lives. It

* Reprinted from *Physical Review* E 67, 062301, 2003.

** E-mail address: baodesong@mail. hz. zj. cn.

appears in desert, avalanche, landslide, and floating ice as well as in traffic flow and engineering chemistry. The regularity of the motion of the discrete system of this kind is quite complicated. As a result, the understanding of these properties and its behavior is rather insufficient. It has been a fascinating phenomenon of much interest to physicists in recent years[1-6]. The behavior of granular flow in a funnel has been studied early where the mass-flow rate is independent of the height of granular in the funnel but related to the exit width of the funnel. The flow rate can be described[5,7] as $Q = Cpb\sqrt{g}(D_0 - kD)^{5/2}$, where D_0 is the opening size of the funnel, ρ_b is the density of the granules, g is the acceleration due to gravity, D is the diameter of the granules, k and c are constants, respectively. For the two-dimensional flow, the equation can be overwritten as $Q = C\rho_b\sqrt{g}(D_0 - kD)^{3/2}$. To and co-workers [8] recently studied the jamming of granular flow in the two-dimensional hopper. The result showed that the jamming probability is a function of the funnel opening. The jamming probability approaches to 1 when the opening size is less than four times of the diameter of the granules, i. e., the jamming happens when $D_0 \leqslant 4D$. In this paper, we will report our studies on the relation between the flow rate Q and speed of the conveyer belt when the granular wafers passes through the bottleneck. Our results may be helpful in the understanding of the transition from free flow to jamming in the traffic flow[9,14].

1. Experimental Setup

The experimental setup is shown in Fig. 1. The copper disks of 6mm in thickness and 16mm in diameter are put on the two-dimensional conveyer belt with the continuously adjustable speed from 0. 10 to 2. 75m/s. On the twain sides are placed a pair of baffles made of aluminum alloy 300mm apart. Monolayer granular wafers are added from the inlet. On the other end, the granular wafers flow out of the exit where the exit is like a bottleneck. The baffle walls make an angle $\phi=90^{\circ}$ with the direction of the moving velocity of the granular wafers. The exit width R can be adjusted continuously, which is kept less than 150mm ensuring the granular wafers to be suffocated by the bottleneck. A weighting sensor with sensitivity of 1.0g and recording rate of 0.02s is placed under the opening exit. The experimental data are transmitted to computer instantaneously, i.e., the granular mass $M(t)$ passing through the opening, the function of time can be recorded. The outflow rate $Q=dM/dt$ was measured for each exit width R. We defined $d=R/D$, where D is the diameter of a granular wafer and d is the exit width in terms of the number of the disk diameters. In our case, the jamming probabilities are close to 1 when d is less than 3.0, we will report only the results with the opening d larger than 3.0.

2. Experimental Results

We measured the outflow rates for eight different exit sizes d from 3.5 to 8 and the speeds of the conveyor belt were changed from 0.16 to 1.16m/s. Figure 2 shows that the relation curves between the flow rates and the speeds of the conveyor belt for different exit sizes. It can be derived from Fig. 2 that the granular flow rate rises as a result of the increase of the velocity of the conveyor belt and the relation ship between the two appears to be nonsimple. The outflow rates Q vary approximately linearly with the speed of the conveyor belt when its speed is low. There is a transition of the flow rate Q when the speed of the conveyor belt v reaches the critical speed v, For example, at a fixed exit width $d=3.5$, the relation between the outflow rate and the speed of the. conveyor belt is shown in Fig. 3.

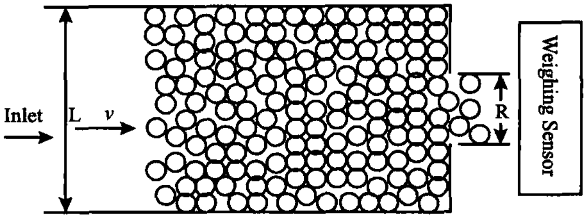

Fig. 1 Schematic diagram of the experiment setup.

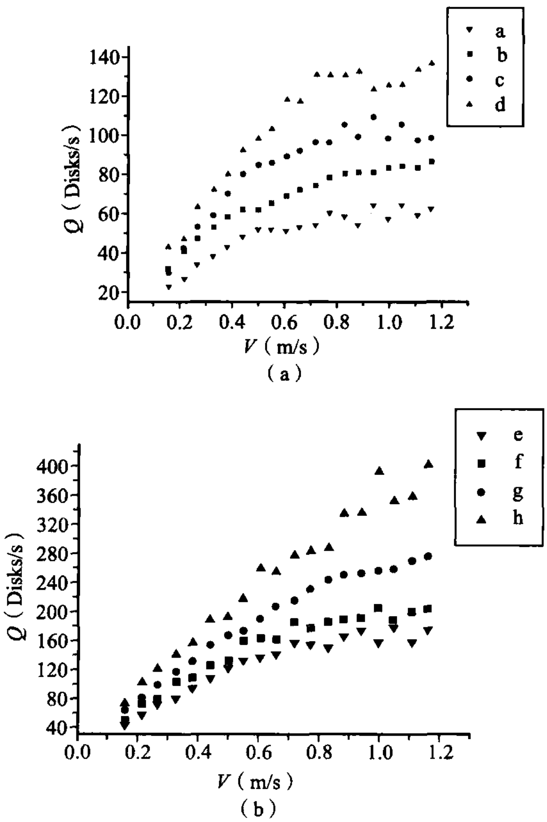

Fig. 2 The flow rate Q relation to the speed of the conveyor belt v in different opening d.

In Fig. 2 (a), *a* to *d* correspond to different openings 3.5, 4.0, 4.5, and 5.0. In Fig. 2 (b), *t* to *h* to different openings 5.5, 6.0, 7.0, and 8.0.

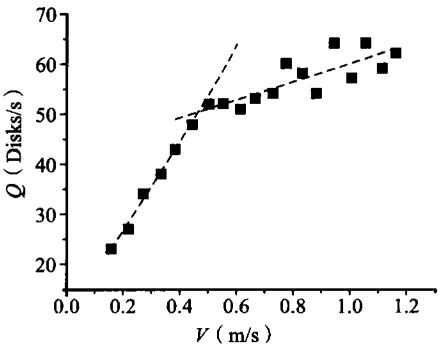

Fig. 3　The flow rate Q relation to the speed of the conveyor belt at a fixed opening $d=3.5$. The dotted line is the result of simulation.

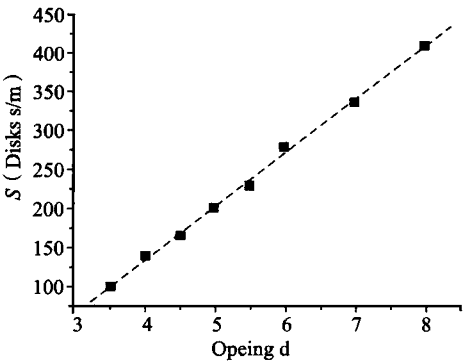

Fig. 4　The S relation to d when $v<v_c$, where $d\equiv R/D$ is the opening in units of disk diameter.

One transition of the flow rate Q emerges when the velocity reaches the critical v_c. And it can be read that v_c equals 0. 44m/s. The Q vs v is linear when $v<0.44$m/s, the slope S equals to 94 (defining $S=\Delta Q/\Delta v$). When $v>0.44$m/s, the Q vs v is quite dispersive. For different openings, the. S vs d is linear when $v<v_c$ as shown in Fig. 4.

The Q-v curve of each opening has its transition point v_c, respectively. The relation between the critical speed v_c, and the exit width d for different openings is shown in Fig. 5. It shows that the v_c is generally linear with the exit width d. In our condition $v_c \approx 0.125d$.

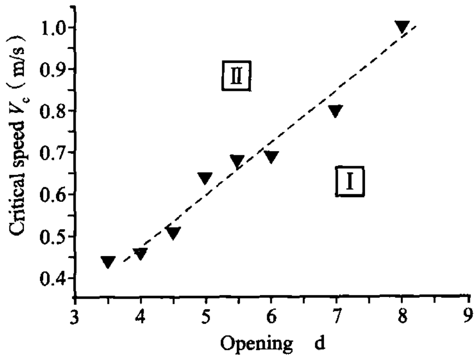

Fig. 5 The critical speed v_c relation to d, where $d \equiv R/D$ is the opening in units of disk diameter.

The driving force of the motion of the granules is friction. The speed of the motion of the granules is identical with the speed of the conveyor belt if the exit width is large enough and the flow rate $Q = \rho v R$. Where ρ is the density of the granules. Therefore, the flow rate Q is linear with the speed v when $v < v_c$. In Fig. 4, the S vs exit width d is linear when $v < v_c$. We can elicit the result that the $\rho = 4280$ disks/m^2 from the slope $(\Delta Q/\Delta v)/\Delta d$ (where $d = R/16$ refers to the width of the opening in terms of the disk diameters) and the equation $Q = \rho v R$. The fraction of the area occupied by granular wafers in the two dimension approximates to 85%. It is analogous to that of the disarray system in two dimension. When $v < v_c$, the density of the granules ρ stays invariable at different exit width. It shows that the flow rate Q is determined by the speed of the conveyor belt and the exit width.

However, when $v > v_c$, the flow rate Q is a nonlinear function with the exit width. The flow rate Q equals to $Q = C\rho v^{\beta}(d-k)^{3/2}$ approximately (where C is a constant, $k = 3.0$, $\beta \approx 1$). It can be derived from the Q-d curve when $v > v_c$ that β equals to I approximately. Furthermore, the flow rate has an obvious fluctuation in Fig. 3. This is due to the arching formed due to the baffle of the exit. In Fig. 5, it is obvious that v_c is linear with respect to d. There is a critical line in Fig. 5. It is divided into two regions labeled region Ⅰ and region Ⅱ, respectively. Region Ⅰ is called linear region, where the flow rate obeys the law $Q=\rho vR$ and region Ⅱ is called nonlinear region, where the flow rate obeys $Q=C\rho v^{\beta}(d-k)^{3/2}$. This is because some disks cannot follow the same speed with the conveyer belt when the exit diminished to critical value d_c, or the speed reached to the critical value v_c. In fact, a transition from dilute flow to dense flow occurred because of the powerful interaction among the disks.

3. Conclusions

In the experiment the motion of monolayer granular wafers on the conveyer belt has been studied. The result shows that the rate of flow Q is influenced chiefly by the following factors: Exit width R and the speed of the conveyor belt v. There is a critical speed v_c for the granular flow Q when the exit width R is fixed. The rate of flow Q increases linearly with the speed v and the exit width R when $v<v_c$. It equals to $Q=\rho vR$ (where the ρ is the two-dimensional density of the granular disks). When $v>v_c$, the flow rate Q is a nonlinear function with the exit width. The flow rate Q equals to $Q=C\rho v^{\beta}(d-k)^{3/2}$ (where C is a constant, $d=R/16$ is the exit width in terms of the number of disk diameters, $k=3.0$, $\beta\approx1$). The transition of the $Q-v$ curve occurs at the speed of v_c. The critical speed v_c is dependent on the exit width d. In our experimental conditions, the critical speed v_c increases linearly with the exit width d. Also, there is a critical exit width d_c when the speed v of the