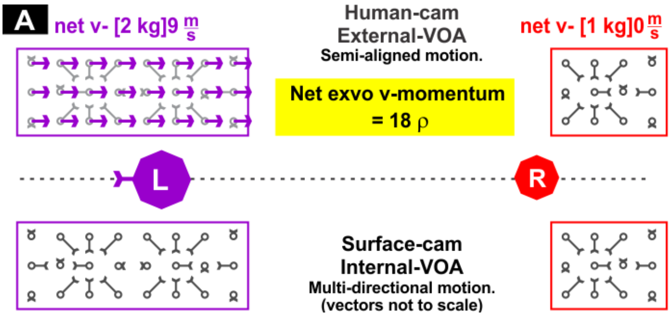


Accelerations Are Atomic Momentum Distribution Rates!

Professor Du-Ane Du

www.Wacky1301SCI.com, *"Looking at serious science, sideways!"*

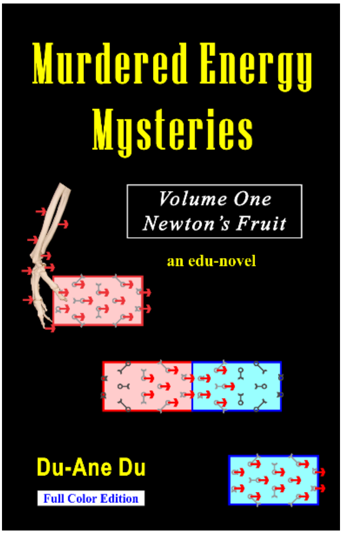
Three sisters, Pico, Hectii, and Tera, the "Space-sci Sherlocks," are traveling through the Asteroid Belt. They use virtual clay ball collisions to deduce how the distribution of atomic momentum causes accelerations.
—Excerpted from *Murdered Energy Mysteries*, Part 1, Chapter 8, by Du-Ane Du, (Amazon, Kindle, ebook 2018, paperback 2021).

"Can I watch atoms do this?" Tera whispered as she activated the 3D visor. "Put me in a large room with pink walls, and hand me two pieces of clay."

“The pictures will work best if the clay is monatomic,” Chip said. “How large?”

“A 1.0 kg ball of monatomic red clay, which we’ll put on the right side of the display,” Tera said. “And a 2.0 kg ball of monatomic lavender clay, which we’ll place on the left side of the display. Attach a surface camera to each clay ball and zoom the surface-cams to the atomic level so I can see what the atoms are doing.”

Excerpted from:



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“The surface-cam will give you the INternal View of the Object’s atoms,” Chip said. “Do you want me to activate some human-level cameras, so you can also observe the EXternal View of the Object’s atoms?”

“That’d be perfect.”

“To make the image easier to interpret,” Chip said, “I’ll set the temperature of the monatomic clay balls so that the invo-atomic average speed is 20 m/s.”

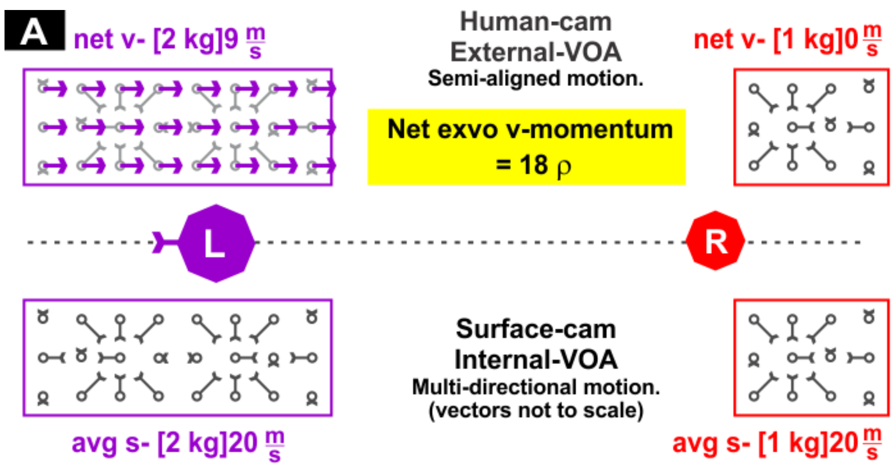
“Excellent,” Tera said, as she moved to the left side of the virtual room and prepared to throw the 2.0 kg lavender-left clay ball at the red-right ball.

“Recording,” Chip said. “I’ll show you individual pictures after the collision is complete.”

Tera reared back and threw the virtual lavender-left ball at the red-right ball. The balls collided, stuck together, and then moved forward as a single ball of clay.

“Stop the motion,” Tera said. “Show me the pictures you took immediately after I threw the lavender ball.”

Chip placed the following on the right wall of the virtual room:



“At the bottom of the illustration, the surface-cam pictures indicate that both balls have an invo-atomic average speed of 20 m/s,” Tera said. “That tells me the clay is very cold.”

“Correct,” Chip said. “In addition, the top pictures show that the red-right ball has an exvo-atomic net velocity of

0 m/s, and the lavender-left ball has an exvo-atomic net velocity of 9.0 m/s. As always, these velocities correspond to the human-level velocities."

"Before I threw the lavender ball of clay, it had a human-level motion vector of 0 m/s," Tera observed. "I was holding it in my hand, so the surface of my glove was in contact with the surface of the virtual clay ball."

"That means there was a glove/ball atomic-interface where your glove contacted the lavender clay ball," Chip said. "During the throw, the glove/ball atomic-interface transferred momentum to the lavender ball. Can you calculate how much momentum your glove transferred to the lavender ball? I'll display the information as you key it in."

"That's easy to calculate," Tera said confidently as she activated her data-input gloves and began keying. "The amount of momentum transferred was:"

$$im\Delta\rho = mv_{final} - mv_{initial}$$

$$im\Delta\rho = \left([2\ kg]9\ \frac{m}{s}\right) - \left([2\ kg]0\ \frac{m}{s}\right)$$

$$im\Delta\rho = \left(18\ kg\frac{m}{s}\right) - \left(0\ kg\frac{m}{s}\right)$$

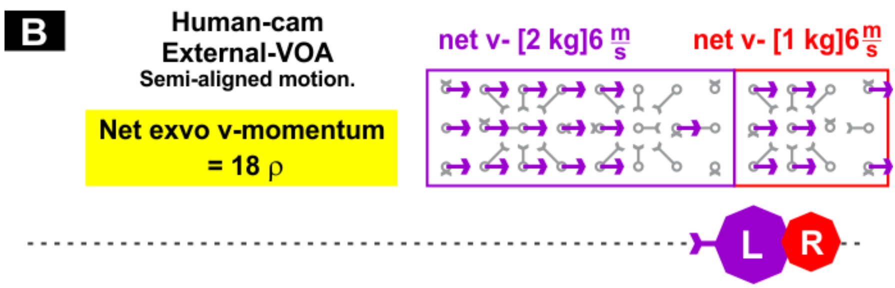
imΔρ = 18 ρ

appeared below the picture.

"Good job, the glove/ball interface transferred 18 ρ to the ball," Chip said.

“That wasn’t hard to calculate,” Tera said. “But how does it relate to the distributing and allotting rate?”

“To answer that, we should observe what the atoms do as the lavender-left ball is colliding with the red-right ball,” Chip said. “Begin with this simplified picture made mid-way through the collision:”



“During the collision, what’s happening to the 18 ρ of momentum that you gave to the lavender-left ball?” Chip said. “By the way, I turned off the invo-atomic view as it doesn’t affect this particular experiment.”

“The clay is monatomic, so in these pictures, the lavender arrows represent both the exvo-atomic velocity and the exvo-atomic v-momentum,” Tera interpreted. “Before the collision, the lavender atoms were moving to the right at the same speed. But now about a third of the momentum has moved into the red-right…it’s sort of like a partial wave!”

“What do you mean, a partial wave?”

“When Pico did her experiments with the pucks, the momentum moved from one puck to another like a wave,” Tera said. “But those pucks were hard, and this clay is soft. Which means, this time the momentum is spreading out in a distribution wave.”

“What do you remember about the principal of mass-equal distribution?” Chip said.

“Let’s see,” Tera reported. “During an inelastic-collision—that’s a collision where things stick together—the momentum of the moving object distributes equally across the entire mass of the two objects as they stick together.”

Tera tapped an access icon and located her notes from the physical science class she took the previous year. Then she searched for, *Principal of Mass-Equal Distribution of Momentum*. The following appeared on her phone:

Principal of Mass-Equal Distribution of Momentum

During an inelastic collision (1) the momentum of Object A will distribute throughout the combined mass of Objects A & B, and (2) the momentum of Object B will distribute throughout the combined mass of

Objects A & B, and (3) the amount of momentum transferred out of each object is the received mass-ratio portion of the available momentum:

$$im\Delta\rho \text{ out of } A = (Mv)_A\left(\frac{m_B}{M_A+m_B}\right)$$

$$im\Delta\rho \text{ out of } B = (mv)_B\left(\frac{M_A}{M_A+m_B}\right)$$

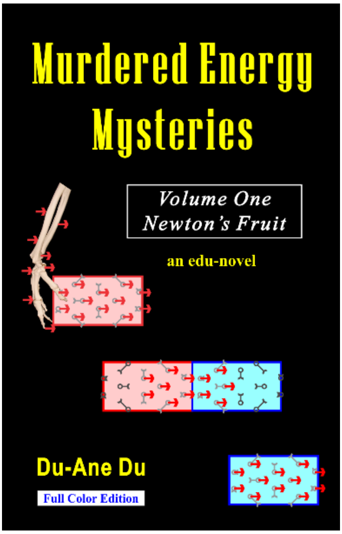
"Put my notes on the right side of the virtual wall," Tera whispered. "That way I have them if I need."

"During the collision," Chip said, as he fulfilled her request, "a lavender/red atomic-interface formed between the two clay balls. As exvo-atomic momentum crossed from the lavender-left ball to the red-right ball, the atoms in both balls began to realign. This re-alignment is a semi-fluid behavior, and it enabled the balls to stick together and move forward as a single unit."

"Would that involve radian/rotational momentum, or forward speed-based momentum?" Tera softly puzzled.

"Because the atoms are changing alignment, this activity will involve a great deal of radian/rotational momentum," Chip said. "In fact, it's the r-momentum that's causing the clay to change its shape.

Excerpted from:



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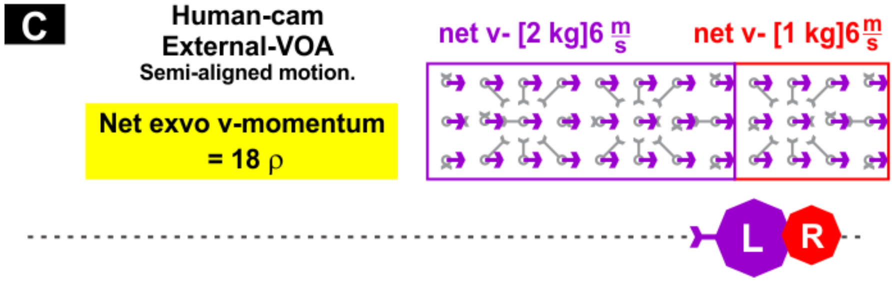
“All of this makes a lot of sense,” Tera said admirably. “The lavender-left ball has twice the mass of the red-right ball, so for both balls to have the same velocity, 1/3 of the lavender-left ball’s momentum moved into the red-right ball.”

“Exactly,” Chip said. “This is the inelastic-collision concept your notes referred to as, the mass-equal distribution of momentum.”

“This can’t be the final picture of the collision,” Tera said. “As some of the lavender-left ball’s momentum is transferred into the red-right ball, the momentum will fan out until it’s evenly distributed among the atoms of both the red and lavender clay.”

“Correct,” Chip said, as he changed the illustration on the left side of her virtual display. “That was a simplified intermediary picture—very simplified. The final picture looks like this:”



"Fabulous," Tera responded. "Now it makes a lot more sense. This picture makes it clear that the original v-momentum has been equally distributed throughout the mass of lavender/red clay."

"Remember, our goal was to find out how much momentum crossed the lavender/red atomic interface," Chip said.

"And we would also like to know how quickly the atoms of the red/lavender atomic interface moved the momentum from one ball to the other," Tera said.

"The amount of momentum transferred out of the lavender-left ball is related to the principal of mass-equal distribution," Chip said. "The exvo-atomic momentum contained in the lavender-left ball was equally distributed over the entire mass of the combined lavender-red ball."

"Which means, the amount of momentum transferred is the received mass-proportional fraction of the momentum that my arm gave to the lavender-left ball," Tera said deductively as her fingers began keying. "The impulse [momentum transfer] out of the lavender-left ball will be:"

$$im\Delta\rho \text{ out of } LL = (Mv)_L\left(\frac{m_R}{M_L+m_R}\right)$$

$$im\Delta\rho \text{ out of } LL = 18\ \rho\left(\frac{1\ kg}{2\ kg+1\ kg}\right)$$

$$\mathbf{im\Delta\rho \text{ out of } LL = 6.0\ \rho}$$

appeared below the picture.

"This tells us, lavender-left ball experienced a momentum change of –6 ρ, because the momentum left the lavender ball," Tera continued, "while the red-right ball experienced a momentum increase of +6 ρ, because the momentum is entering the red ball."

"Nicely done," Chip said. "If the collision and momentum transfer took 0.1 s, what was the contac- ρ-force-rate of the lavender/red atomic interface?"

"I divide, like before," Tera said. "The calculations will be:"

$$L/R\ \rho\text{-}\underline{\mathbf{F}}orce\text{-}rate = \frac{im\Delta\rho}{time}$$

$$L/R\ \rho\text{-}\underline{\mathbf{F}}orce\text{-}rate = \frac{6\ \rho}{0.1\ seconds}$$

L/R ρ-<u>F</u>orce-rate = 60 ρ/s, or 60N for 0.1 s

appeared below the picture.

Tera nodded triumphantly, "My calculations show, the lavender/red atomic interface accomplished a force-rate of 60 momentums per second."

"Good," Chip said. "And the momentum was distributed across the combined mass of both clay balls."

"That means both balls experienced a momentum allotting and distributing rate," Tera said. "The ***<u>a</u>***llotting rate is the force-rate divided by the mass. Since the balls had different masses, they must've experienced different ρ-allotting rates."

"Why don't you begin with the lavender-left ball."

"The lavender-left ball has a mass of 2.0 kg," Tera said. "It gave rightward momentum to the red-right ball. The lavender-left ball lost momentum, so it experienced a negative force-rate. That means the calculations for the accel- ***a***llotting rate will be:"

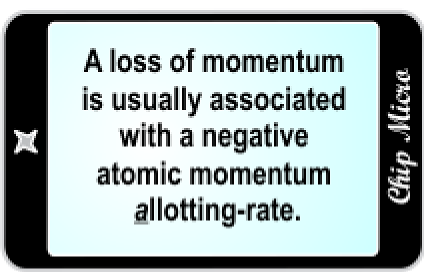
$$\rho\text{-}\underline{\boldsymbol{a}}\textit{llotting rate, LL} = \frac{(\rho\text{-}Force\text{-}rate)}{mass}$$

$$\rho\text{-}\underline{\boldsymbol{a}}\textit{llotting rate, LL} = \frac{-60\ \rho/s}{2\ kg}$$

$$\boldsymbol{\rho\text{-}\underline{a}\textit{llotting rate, LL} = -30\ \frac{\rho/s}{kg}\ \text{or}\ -30\ \frac{m}{s^2}}$$

appeared below the picture.

"Wow, the lavender-left ball ***g***ave, ***a***llotted, and distributed the loss of momentum at a rate of –30 ρ/s per kilogram, that's quite a deceleration," Tera concluded.



"What about the red-right ball?" Chip said.

"The red-right ball had half the mass, and it suffered the most damage during the collision."

"6 ρ of momentum left the lavender-left ball and went into the red-right ball," Chip said.

"The red-right ball gained momentum, so it must've experienced a positive force-rate," Tera appraised as she keyed. "The calculations for the allotting rate of the atoms inside the red-right ball will be:"

$$\rho\text{-}\underline{\boldsymbol{a}}llotting\ rate,\ RR = \frac{(\rho\text{-}\boldsymbol{F}orce\text{-}rate)}{mass}$$

$$\rho\text{-}\underline{\boldsymbol{a}}llotting\ rate,\ RR = \frac{+60\ \rho/s}{1\ kg}$$

$$\boldsymbol{\rho\text{-}\underline{a}llotting\ rate,\ RR = +60\ \frac{\rho/s}{kg}\ or\ +60\ \frac{m}{s^2}}$$

appeared below the picture.

"Twice as high, the atoms in the red-right ball ***g***ave, ***a***llotted, and distributed the momentum at a rate of 60 ρ/s per kilogram," Tera continued. "That means the acceleration of the red-right ball was twice the deceleration of the lavender ball. No wonder the red ball smashed so much!"

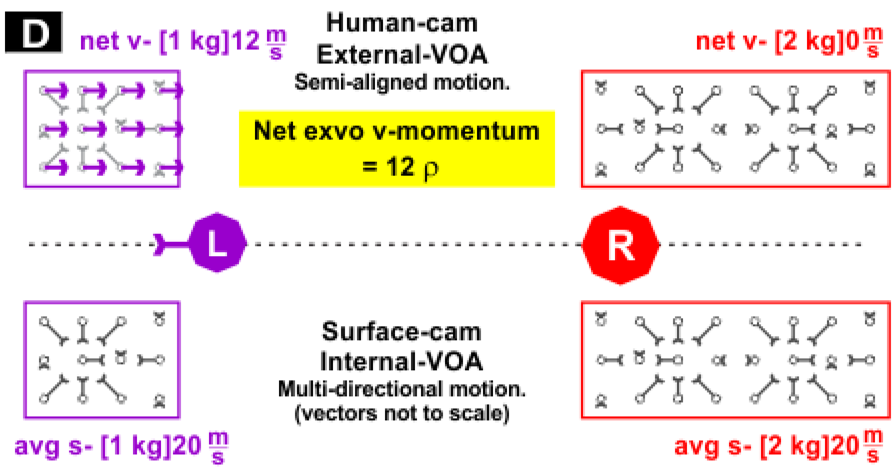
"Does the allotting/giving and distributing rate of an object seem logical now?" Chip said.

"I think I'm beginning to understand," Tera said radiantly. "But this is sort of fun. Now I want to throw a 1.0 kg lavender clay ball at a 2.0 kg red ball. Put the lavender ball in my hand."

Tera extended her virtual glove, and a 1.0 kg lavender-left ball of clay appeared in her hand. A new 2.0 kg red-right ball appeared several feet to her right. She imitated her favorite softball pitcher—wound up and threw the lavender-left ball at the red-right ball. “Smash,” she said beneath her breath, as the balls collided and glided away into the distance.

“Show me a picture of what was happening just before the collision,” Tera said.

“Here” Chip said, as he placed the following on the left side of her visor screen:



“Good morning, Tera,” Pico hailed sweetly, as her virtual image appeared to Tera’s right.

“Good morning, Pico,” Tera said melodically. “Is everyone awake?”

“Daddy is checking our flight path, Hectii is still asleep, I ate some apple cereal, and I wandered over to see what you’re doing.”

“This is interesting,” Tera admitted. “I’m studying what happens when I throw a 1.0 kg clay ball at a 2.0 kg clay ball.”

"Chip, show me the images that Tera has been looking at," Pico said.

Chip showed both girls a 3D recording of Tera throwing the lavender-left ball at the red-right ball.

"They stuck together," Pico said. "The experiments I did the other day involved pucks that bounced apart. Is the math the same?"

"This is called an inelastic collision," Tera said instructively. "Before I threw the balls, Chip set the temperature of the experiment so that the atoms of the monatomic red and lavender clay all have an average invo-atomic forward speed of 20 m/s."

"Invo-atomic speed relates to temperature," Pico said. "20 m/s means the clay must be very cold. In the top pictures, the red clay ball has an exvo-atomic net velocity of 0 m/s."

"That tells us it's not moving."

"But the lavender-left ball is moving," Pico noted. "If you look at the top lavender picture, you can see that the lavender-left ball has a net v-momentum of 12 kgm/s, which means when you threw the ball, you gave it 12 ρ of exvo-atomic momentum."

"Excellent deduction," Tera said.

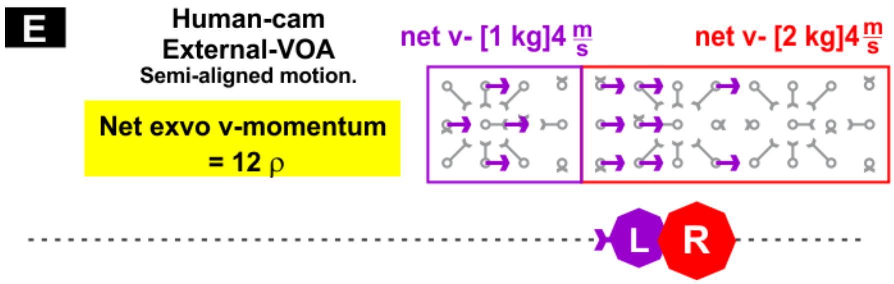
"Ok Chip," Pico said. "What happened to the atoms as the lavender-left ball hit the red-right ball?"

“First, a lavender/red atomic-interface formed, Tera said.

“If I were to predict a final answer,” Pico said. “I would say that an invo-atomic impulse wave formed and… but this is clay. Can an impulse wave travel from one end of a clay ball to the other?”

“Chip,” Tera said. “Show her a simplified illustration of what happened mid-way through the collision.”

“Yes. First, I should note that the invo-atomic view does not affect this experiment. So, I’ll only include the exvo-atomic views,” Chip said, as he placed the following on the left side of their visor-displays:



“Look at the purple arrows! It’s kind of like a wave,” Pico diagnosed, “or maybe a partial wave. I guess that’s because the clay was soft, and the balls squished during the collision.”

“What makes it different?” Tera prompted.

"The clay is monatomic, so the lavender arrows represent both the exvo-atomic velocity and the exvo-atomic momentum," Pico said. "Before the collision, the lavender atoms were moving forward at the same speed. But only part of the momentum has moved into the red…is there a way to predict how much momentum moves from one object to the other?"

"We studied this in school last year," Tera confessed. "The balls stuck together, so the momentum can't simply move from one object to the other."

"The momentum must spread out and fill all of the mass in both objects," Pico deduced. "Is there a scientific rule about how this happens?"

"They call it the principal of mass-equal distribution of momentum," Tera said.

"That's very logical," Pico said. "After all, during a stick-together collision, the momentum of the moving object will distribute equally across the entire mass of the two objects as they stick together—if it doesn't distribute evenly, then part of the clay will move faster, and part of the clay will move slower."

"It's a type of momentum allotting rate!"

"An accel- ρ-allotting and distributing rate!" Pico said deductively. "Tera, this is so logical! The atoms of both balls are allotting and distributing the momentum across the entire mass of both balls!"

Tera grinned ecstatically. “Exactly. And there’s a simple mass-ratio equation that predicts how much momentum will cross the atomic-interface from one object to the other.”

“How’s it work?” Pico said.

“Chip can explain it,” Tera said.

“During the collision,” Chip said, “a lavender/red atomic-interface formed between the two clay balls. As exvo-atomic momentum crossed from the lavender-left ball to the red-right ball, the atoms in both balls began to realign. This realignment is a semi-fluid behavior, and it enabled the balls to stick together and move forward as a single unit.”

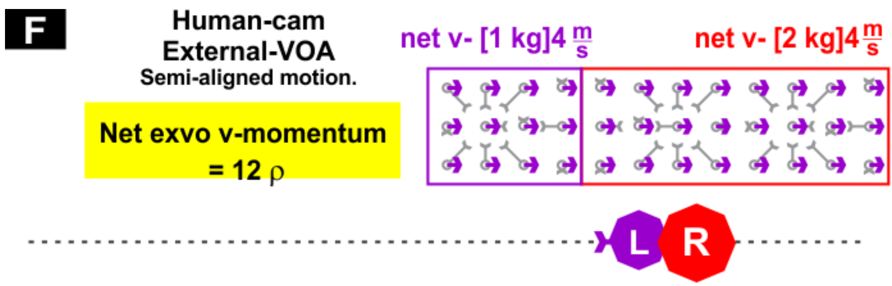
“The red-right ball has a mass of 2.0 kg, and the lavender-left ball has a mass of 1.0 kg,” Pico said. “Which means, for both balls to have the same velocity, 2/3 of the lavender-left ball’s exvo-atomic momentum had to move into the red-right ball.”

“Exactly,” Tera said affirmed. “It’s all about the mass-equal distribution of the exvo-atomic momentum.”

“You said this is a simplified picture of what’s happening at the beginning of the collision,” Pico recalled. “It seems to me, the lavender-ball’s r-s-t momentum must’ve spread out and bounced around inside both clay balls.”

“That’s right,” Tera said. “Show her the final picture, Chip.”

“Ok,” Chip said. “The final picture looks like this:”



"That's what I expected to see," Pico said. "The momentum is now equally distributed throughout the mass of lavender/red clay balls—all of the atoms are moving to the right at the same velocity."

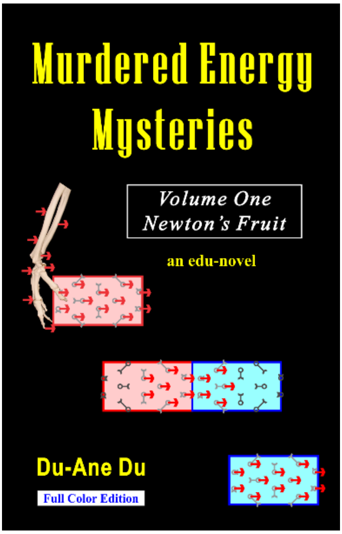
Tera's avatar laughed. "And that's the principal of mass-equal distribution of…"

"Hold on," Pico said. "We're the Space-sci Sherlocks, and whenever we can, we want to focus on scientific facts. This must be a new scientific fact."

"Why?"

"Because whenever two objects collide and stick together, the momentum waves are going to bounce around inside the objects until the atoms have the same net velocity."

Excerpted from:



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"That's true," Tera said. "But what should we call this new fact?"

"It involves the allotting and distribution of exvo-atomic momentum," Pico said. "Let's call it the exvo-atomic fact #2 of mass-equal distribution of momentum."

"Chip, adjust my notes, and the exvo-atomic information, and display them so Pico can see."

"Here," Chip said as the following appeared on their displays:

EXVO-Atomic Fact #2 of Mass-Equal Distribution of Momentum

During an inelastic collision, (1) the exvo-atomic v-momentum of Object A will distribute throughout the combined mass of Objects A & B, and (2) the exvo-atomic v-momentum of Object B will distribute throughout the combined mass of Objects A & B, and (3) the amount of momentum transferred out of each object is the received mass-ratio portion of the available momentum:

$$im\Delta\rho \text{ out of } A = (Mv)_A\left(\frac{m_B}{M_A+m_B}\right)$$

$$im\Delta\rho \text{ out of } B = (mv)_B\left(\frac{M_A}{M_A+m_B}\right)$$

"That's an incredible explanation," Pico approved.

"Now, can you calculate the momentum allotting rates that occurred during our experiment?" Tera asked suggestively.

"Maybe," Pico said. "First we need to know how quickly the atoms of the lavender/red atomic-interface moved the momentum from the lavender-left ball to the red-right ball."

"To find that you need to use exvo-atomic fact #2 of mass-equal distribution," Tera said. "The amount of momentum transferred is the received mass-proportional fraction of the momentum that my arm gave to the lavender ball."

"Show me," Pico said.

Tera smiled warmly as she keyed. "Before the collision, the lavender-left ball had a momentum of 12 kgm/s. Based on that, the amount of momentum transferred out of the lavender ball will be:"

$$im\Delta\rho \ out \ of \ LL = (mv)_L\left(\frac{M_R}{m_L+M_R}\right)$$

$$im\Delta\rho \ out \ of \ LL = 12\ \rho\left(\frac{2\ kg}{1\ kg+2\ kg}\right)$$

$$\boldsymbol{im\Delta\rho \ out \ of \ LL = -8\ \rho}$$

appeared below the picture.

"That tells us the lavender-left ball will experience a momentum change of –8 ρ," Pico considered aloud, "while the red-right ball experienced a momentum increase of +8 ρ."

"Exactly," Chip said. "If the collision took 0.1 s, contact force-rate would be:"

$$L/R\ \rho\text{-}\underline{\boldsymbol{F}}orce\text{-}rate = \frac{im\Delta\rho}{time}$$

$$L/R\ \rho\text{-}\underline{\boldsymbol{F}}orce\text{-}rate = \frac{8\ \rho}{0.1\ seconds}$$

***F* = 80 ρ/s, or 80N for 0.1 s**

appeared below the picture.

"Fabulous, that tells us the lavender/red atomic interface performed a force-rate of 80 momentums per second," Tera said. "Now think about this, the momentum was distributed across the combined mass of both clay balls."

"That means the red-right ball of clay experienced an allotting/distributing rate associated with the gain of momentum," Pico surmised. "And at the same time, the lavender-left ball of clay experienced an allotting rate associated with the loss of momentum. Were both rates the same?"

Tera shook her head. "The allotting rate is the force-rate divided by the mass. Since the balls had different masses, the atoms in the balls must've distributed the momentum at different rates."

"I see," Pico whispered as she paused to consider. "The force-rates at the atomic interface are equivalent, but the allotting rates inside the clay balls will be different. That means the calculations for the allotting/giving rate of the red-right ball will be:"

$$\rho\text{-}\underline{\boldsymbol{a}}llotting\ rate,\ RR = \frac{(\rho\text{-}\boldsymbol{F}orce\text{-}rate)}{mass}$$

$$\rho\text{-}\underline{\boldsymbol{a}}llotting\ rate,\ RR = \frac{+80\ \rho/s}{2\ kg}$$

$$\boldsymbol{\rho\text{-}\underline{a}llotting\ rate,\ RR = +40\ \frac{\rho/s}{kg}\ or\ +40\ \frac{m}{s^2}}$$

appeared below the picture.

"Good job," Tera commended. "Your calculations show us, the atoms in the red-right ball ***g***ave, ***a***llotted and distributed the momentum throughout the mass of the red ball at a rate of 40 momentums per second, per kilogram."

"You still think the lavender-left ball will experience a different allotting rate?" Pico said.

Tera nodded. "The lavender-left ball had half the mass—"

"—and it suffered the most damage during the collision," Pico said.

"My turn," Tera said gleefully. "The calculations the allotting rate of the atoms inside the lavender-left ball will be:"

$$\rho\text{-}\underline{\boldsymbol{a}}llotting\ rate,\ LL = \frac{(\rho\text{-}\boldsymbol{F}orce\text{-}rate)}{mass}$$

$$\rho\text{-}\underline{\boldsymbol{a}}llotting\ rate,\ LL = \frac{-80\ \rho/s}{1\ kg}$$

$$\boldsymbol{\rho\text{-}\underline{a}llotting\ rate,\ LL = -80\ \frac{\rho/s}{kg}\ or\ -80\ \frac{m}{s^2}}$$

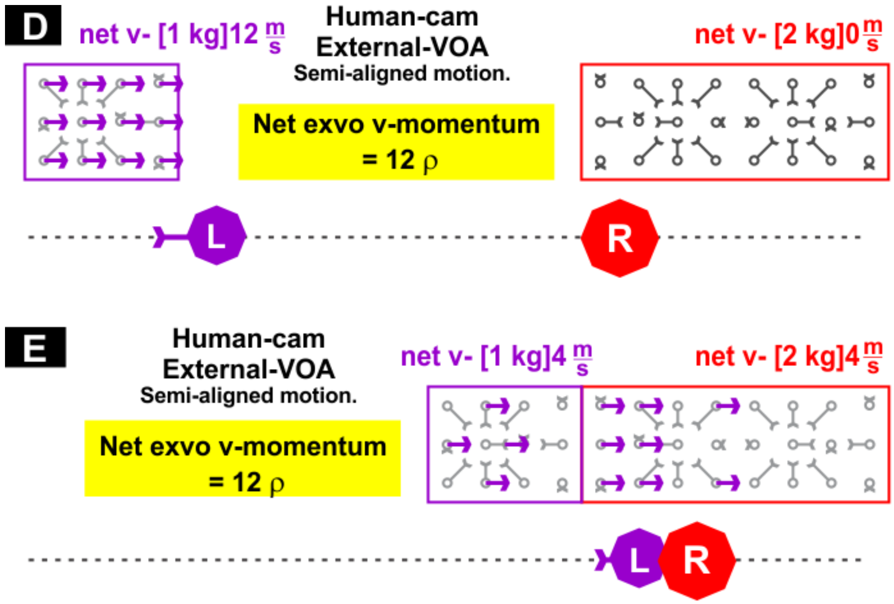
appeared below the picture.

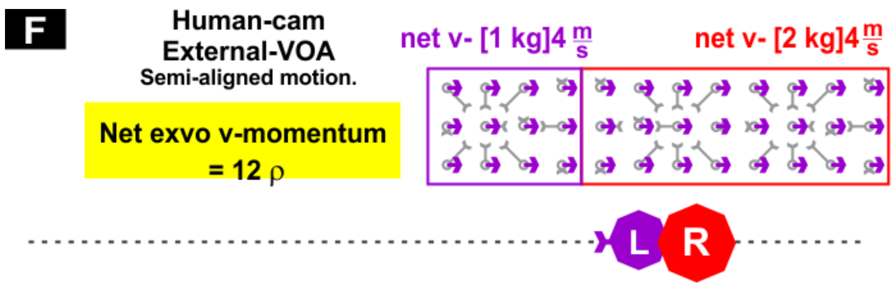
“Twice as high, and in the opposite direction,” Pico proclaimed, a touch of awe in her voice. “That means the deceleration of the lavender ball was twice the rate of acceleration of the red ball. No wonder the lavender-left ball smashed when it hit the red ball!”

“This allotting rate idea makes a lot of sense!” Tera joyously declared.

“And the distribution of the momentum is so easy to see when you use the atomic zoom cameras,” Pico said. “Chip show us all three pictures in order.”

“Certainly,” Chip said, as he placed the following on their displays:





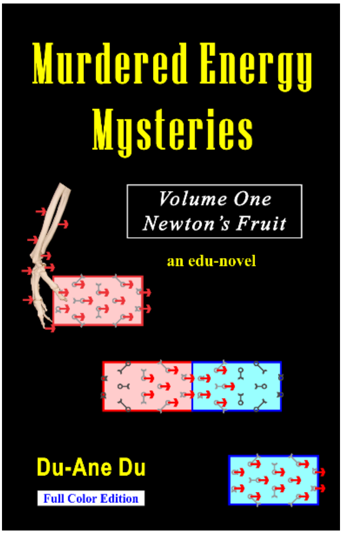
"The momentum is moving around like a distribution wave," Tera said.

"The distribution/allotting wave is causing the lavender-left ball to decelerate," Pico said, "And at the same time, the distribution/allotting wave is causing the red-right ball to accelerate."

"That sounds like a new scientific fact," Tera said. "What should we call it?"

"The exvo-atomic momentum allotting-rate causes human-level acceleration," Pico thought aloud. "This'll be our exvo-atomic fact #3 of acceleration."

Excerpted from:



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"We know that the measured amount of acceleration is numerically equal to the allotting rate," Tera said.

"Good," Pico said, "and that means the **exvo-atomic fact #3 of acceleration** should state, human-level acceleration is a direct result of an object's ρ-allotting rate for the given situation. As momentum-increase or momentum-loss is distributed throughout an object's mass, the object will change velocity—creating the human-level observation of acceleration."

"That's a brilliantly worded scientific fact," Tera exclaimed. "Once again, the Space-sci Sherlocks have extended their stupendous series of deductions!"

* * *

Murdered Energy Mysteries seeks to increase understanding of the various forms of momentum and momentum transfer, as well as the various forms of energy and energy transfer. The lack of understanding on the part of the scientific community is substantial, and more research needs to be done.

—Du-Ane Du, author of the edu-novel *Murdered Energy Mysteries* (Amazon, Kindle, e-book 2018, paperback 2021.)

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