The Program in

Interdisciplinary Studies

at IAS, Princeton

Widely Interdisciplinary Research

幅広い学際的な研究のために

Piet Hut（ピート　ハット）
Institute for Advanced Study
Princeton, NJ, USA

Kavli IPMU, April 19, 2012

Institute for Advanced Study

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- Historical Studies
- Mathematics
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barty Appoin

Art and Its Spaces Lecture Series Continues

Planning Board Unanimously Approves IAS

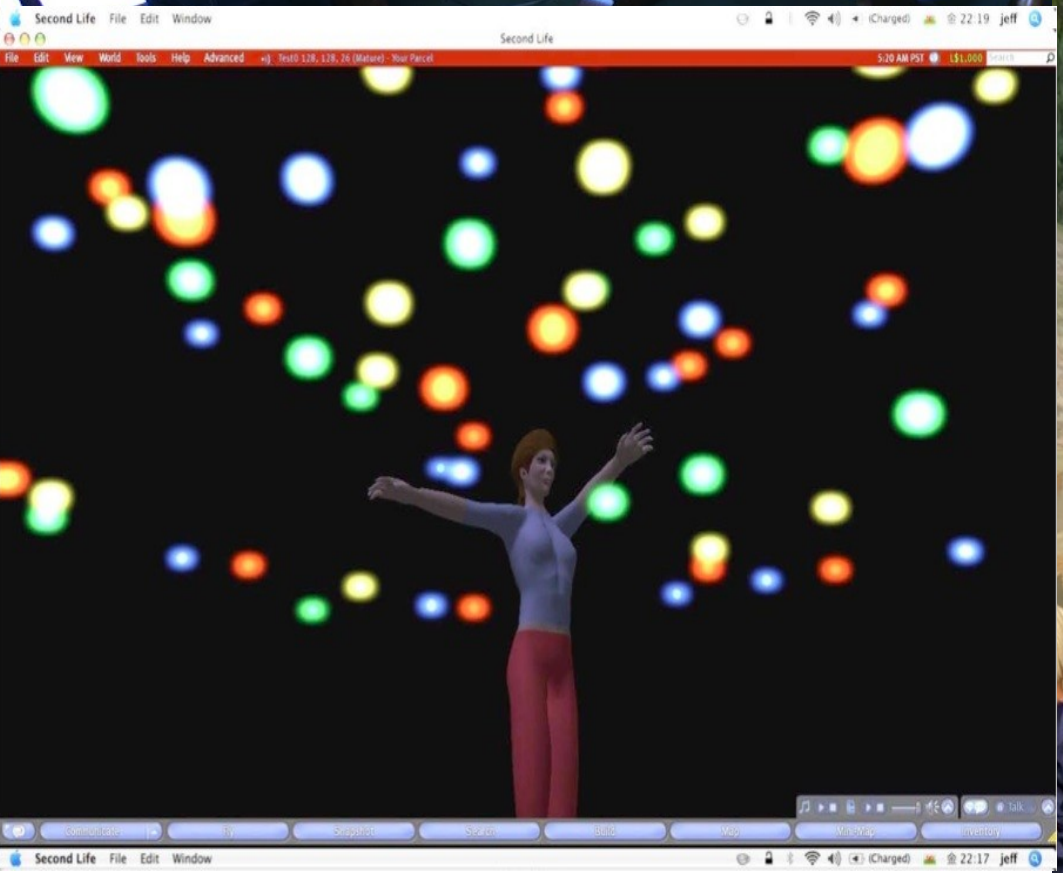
Report for the Academic Year 2010–2011

An example involving interdisciplinary research:

Astrophysics & Computer Science

Virtual Worlds


s : start/stop recording : READY
p : playback/live streams : LIVE STREAM
t : skeleton tracking : TRACKING USERS: 2
(/) : smooth skely (openni) : 0.1
h : hand tracking : TRACKING HANDS: 3
f : filter hands (custom) : NOT FILTERING
[/] : filter hands factor : 0.1
; / ' : smooth hands (openni) : 0.1
m : drawing masks : SHOW
c : draw cloud points : OFF
b : cloud user data : SHOW BACKGROUND
: 500

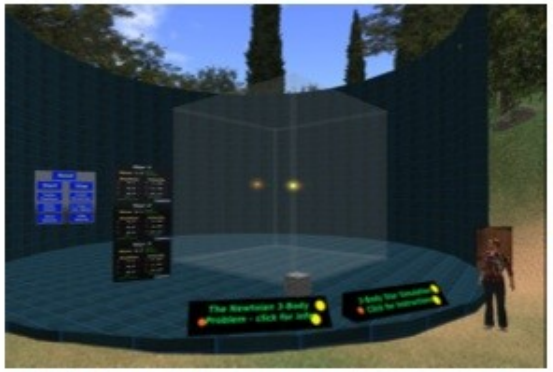

Second Life File Edit Window
Second Life
File Edit View World Tools Help Advanced
Second Life File Edit Window


Enriched halos and Globular Clusters
What is the mode of star formation in self-enriched halos at z>10?
Could be progenitor of metal poor globular clusters (Santos 2003)
If so, some of these globular clusters could naturally have an Intermediate Mass Black Hole at their center
Dynamic fingerprints expected (Trenti et al. 2007)
Quenching of mass segregation very promising:
Gill, Trenti et al. (2008)
Pasquato, Trenti et al. (2009), ApJ in press yesterday astro-ph!

Visualization of N-body Simulations in Virtual Worlds

Knop, R (MICA), Ames, J (Genkii), Djorgovski, G (Caltech), Farr, W (Northwestern), Hut, P (IAS), Johnson, A (Genkii), McMillan, S (Drexel), Nakasone, A (Nat'l Inst. of Informatics, Japan), Vesperini, E (Drexel)

The 3-Body Problem in Second Life



What is Second Life?

Second Life™ (SL) is an online virtual world. Although it bears superficial similarity to massive multiplayer online games, it is rather a tool that may be used for many things, including immersive online collaboration.

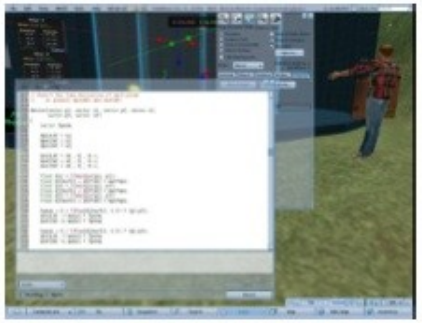
A Second Life account is free; http://secondlife.com

SL is supported on Linux, MacOS, and Windows. It will perform better with a recent ATI or NVidia 3d graphics card with dedicated video memory.

The Linden Scripting Language

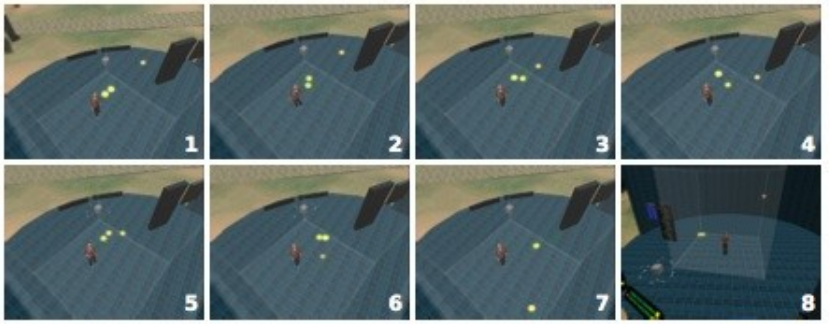
Most of the content was built by the users using the built-in 3d modeling tools. You can assign behaviors to objects you've built by writing scripts. LSL is a simple (but limited!) procedural language superficially similar to C, with an API that allows interaction with scripted objects.

LSL is a limited language (it doesn't have arrays), and runs slowly. However, it has a powerful set of functions for controlling the SL environment.



On the Web : http://www.manybody.org/wiki/index.php/LSL_3-Body

In-World : http://slurl.com/secondlife/StellaNova/205/50/26



A sample 3-body simulation: the simulation uses the 4th-order Runge-Kutte integrator. It solves on a fixed time step, and commands stars to move around as the solution is being calculated. As LSL doesn't have arrays, all loops are unrolled. In this sample calculation, a $2M_\odot$ circular binary is visited by a $0.6M_\odot$ interloper. The stars dance, a tight binary is formed, and one star is ejected.

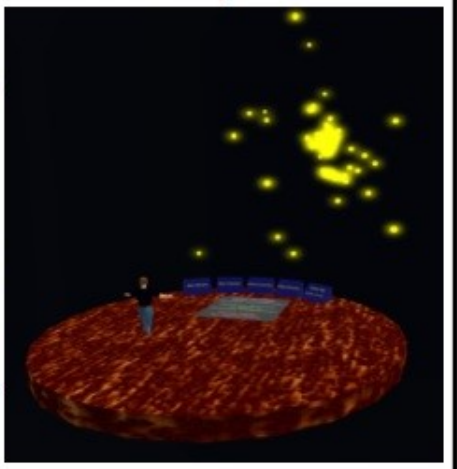
The N-Body Problem in OpenSim

What is OpenSim?

OpenSim is a 3D applications platform. It started as a virtual world server using the same protocols as SL so that the open source SL viewer could connect to it. Because it's open source, anybody can download it and extend it using a powerful modern computer language (C#). What's more, OpenSim aims to provide an API so that others may build applications on top of it. While still in the alpha stage with an API subject to further changes, it promises to be much more than an "open source SL clone".

There are several grids out there running OpenSim, including OSGrid and ScienceSim. You can connect to OpenSim grids using the same viewer software used to connect to Second Life.

For more information, go to http://www.opensimulator.org



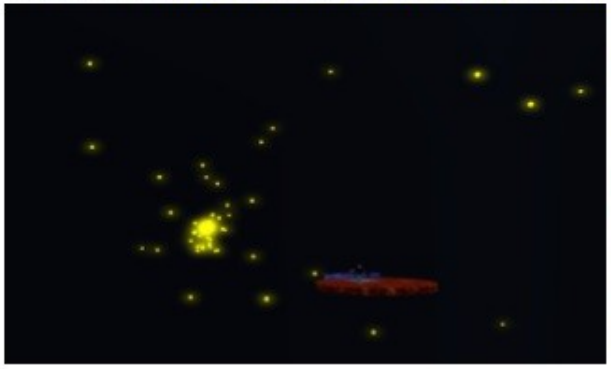
A cluster simulation with 64 stars runs in the MICA StarSim region on ScienceSim, observed by an avatar in front of control panels.

The NewtonPlugin OpenSim Physics Engine

By default, OpenSim uses the OpenDynamics Engine (http://ode.org) to simulate collisions between objects and avatars. Because OpenSim is open source, we were able to replace the physics engine with an N-body solver. The NewtonPlugin engine treats all objects marked as physical as gravitating particles, and updates their positions and velocities based on their mutual gravitational interaction using a direct N-body code. The result is an N-body calculation performed not by a script, but by the server itself. It's useful for demonstrations, and works with small N (<100) on modest hardware. The code has several integrators implemented. The simulation shown in the screen shots comes from a run with a simple first-order Forward Euler integrator.

You can find this engine running in the "MICA StarSim" region on ScienceSim. You can also download it and run a standalone instance of OpenSim on your laptop or desktop.

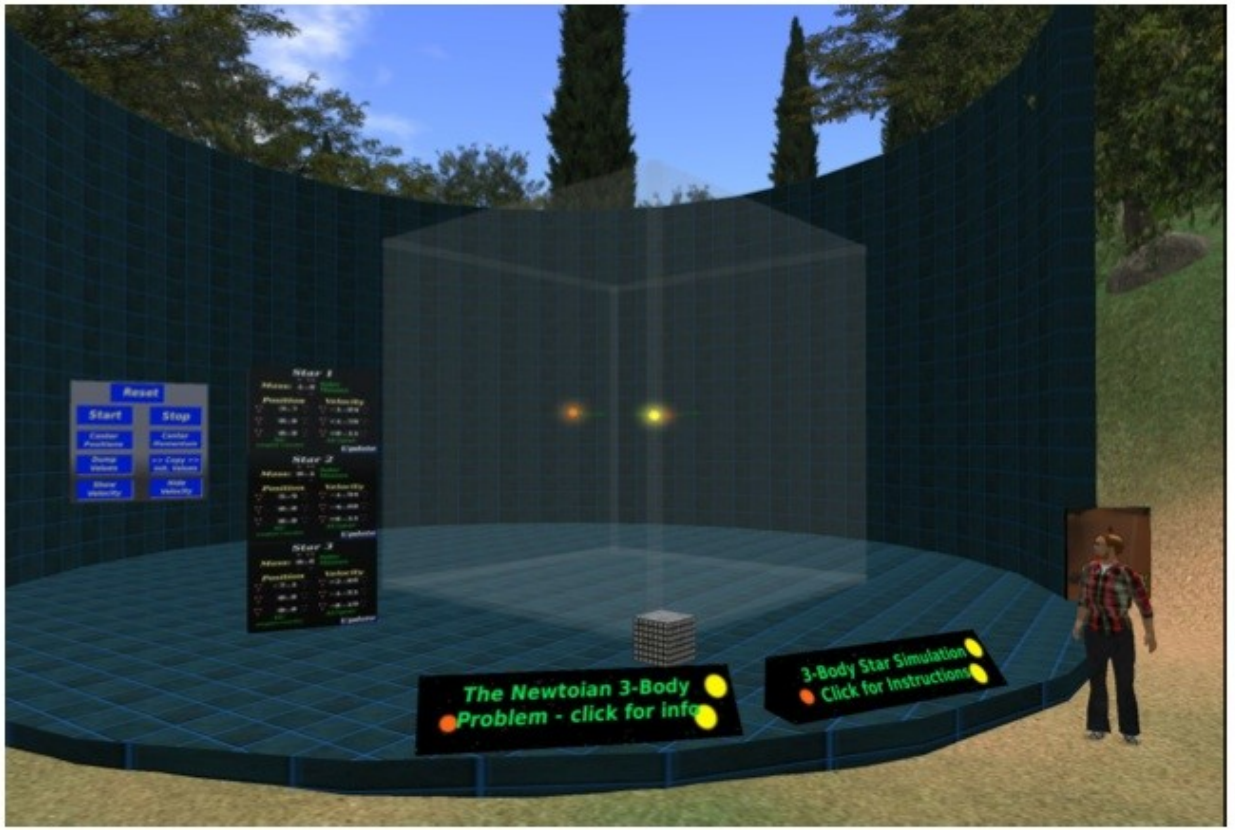
On the Web : http://www.manybody.org/wiki/index.php/NewtonPhysics



ScienceSim

ScienceSim is an OpenSim grid originally supported by Intel for the Supercomputing 2009 conference. It is trying to become a foundation that will produce a stable distribution of OpenSim. The grid focuses on education and research uses. To connect, visit http://sciencesim.com

The 3-Body Problem in Second Life



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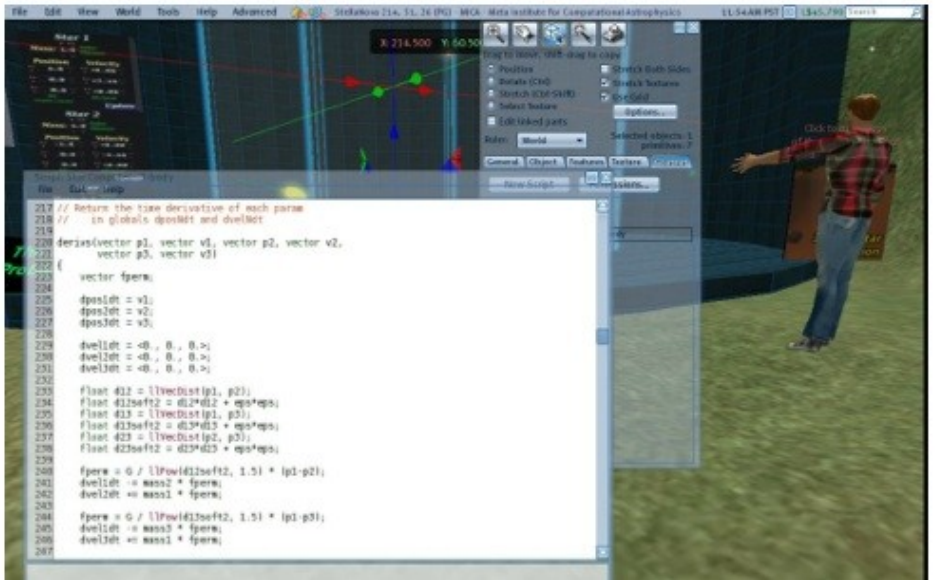

The N-Body Problem in OpenSim

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Interdisciplinary Studies

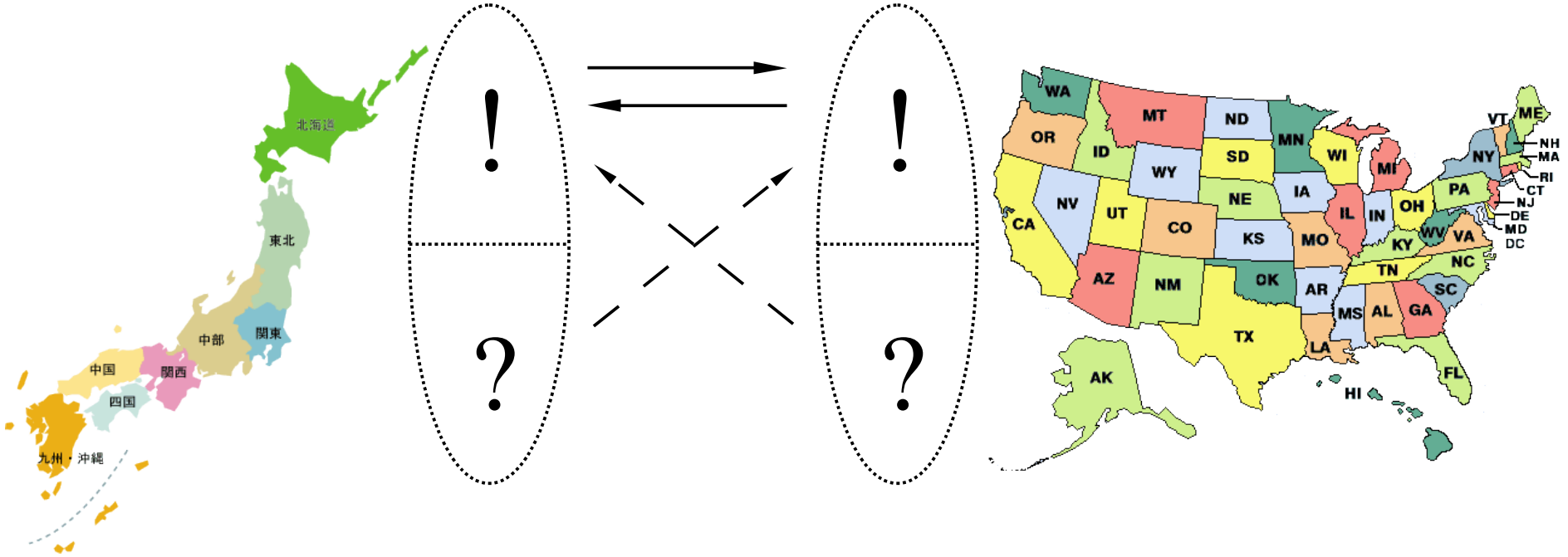
The Program in Interdisciplinary Studies provides a meeting place for members from the Institute for Advanced Study to engage in conversations and research that addresses the wider questions that rarely get asked within individual disciplines.

What is the nature of knowledge in different academic areas, in the humanities, the social sciences, the natural sciences, and mathematics? How may these fields stimulate each other? And how do such types of knowledge compare with those found in the arts, in the business world, in ancient traditions, and in daily life?

In a discussion between members of two cultures, there are two ingredients that are necessary:

1) both sides must share the *explicit knowledge* from both sides;

2) both sides must share the *tacit knowledge* from both sides.



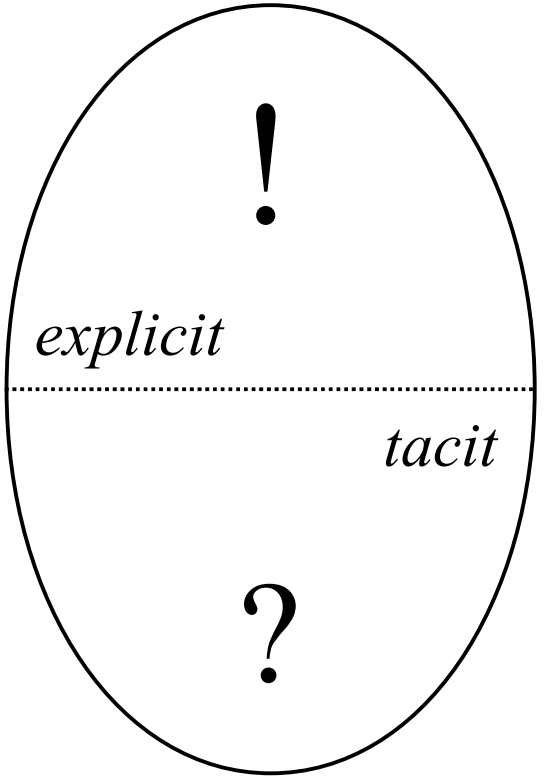
The main problem is:

each side can of course *use* its own tacit knowledge, but

each side usually does not *know* its own *tacit knowledge.*

Therefore, each side has to become aware of its own knowledge:

what is needed is “knowledge of knowledge”



An example: In the New York Times, an American journalist flew in an airplane with the Japanese prime minister and a group of Japanese journalists. The American journalist wrote:

"The Japanese journalists continued to complain about the heat"

and he did not realize that 暑いですねえ has an *implicit* or *tacit* meaning, which is quite different from the *explicit* meaning.

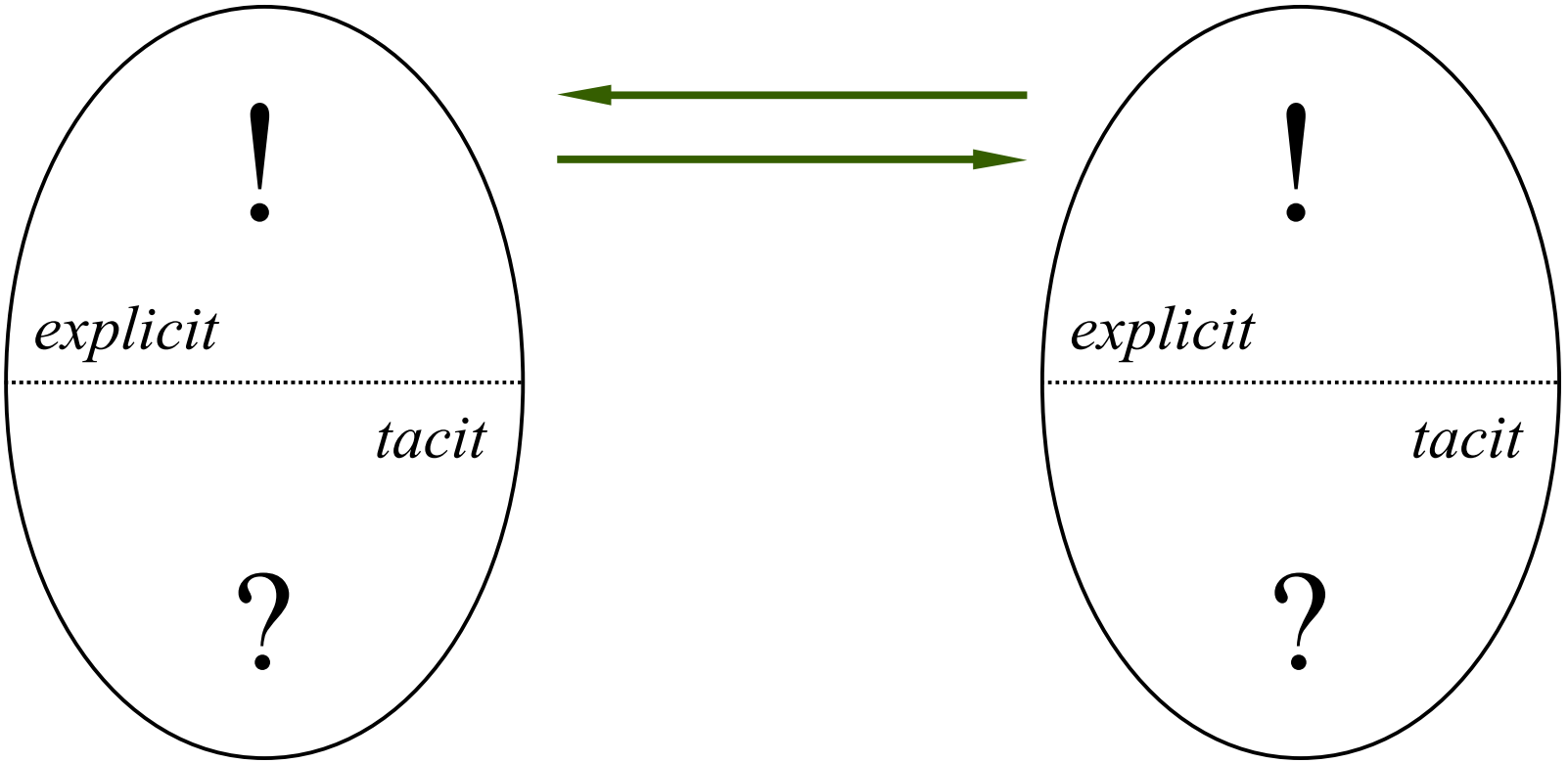
explicit meaning: 暑いですねえ : It is hot, isn't it!

tacit meaning: 暑いですねえ : this can have many different meanings, depending on context: just a friendly sharing of feelings; or a sign to take off your coat and neck tie, to be more informal.

For the American journalist, visible knowledge: those Japanese just keep complaining.

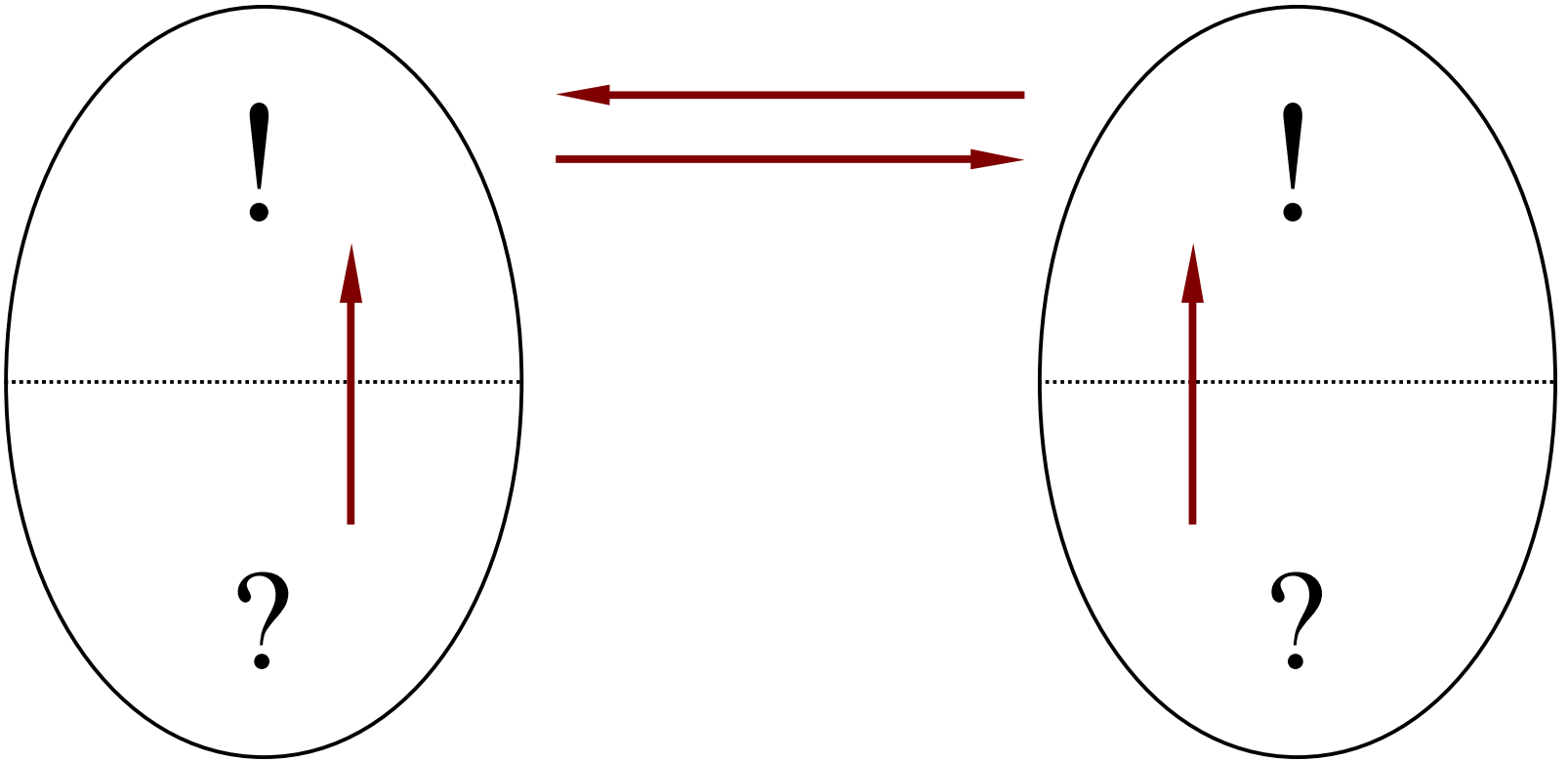
For the Japanese journalists, invisible knowledge: let us be more relaxed with each other.

Knowledge diagram:



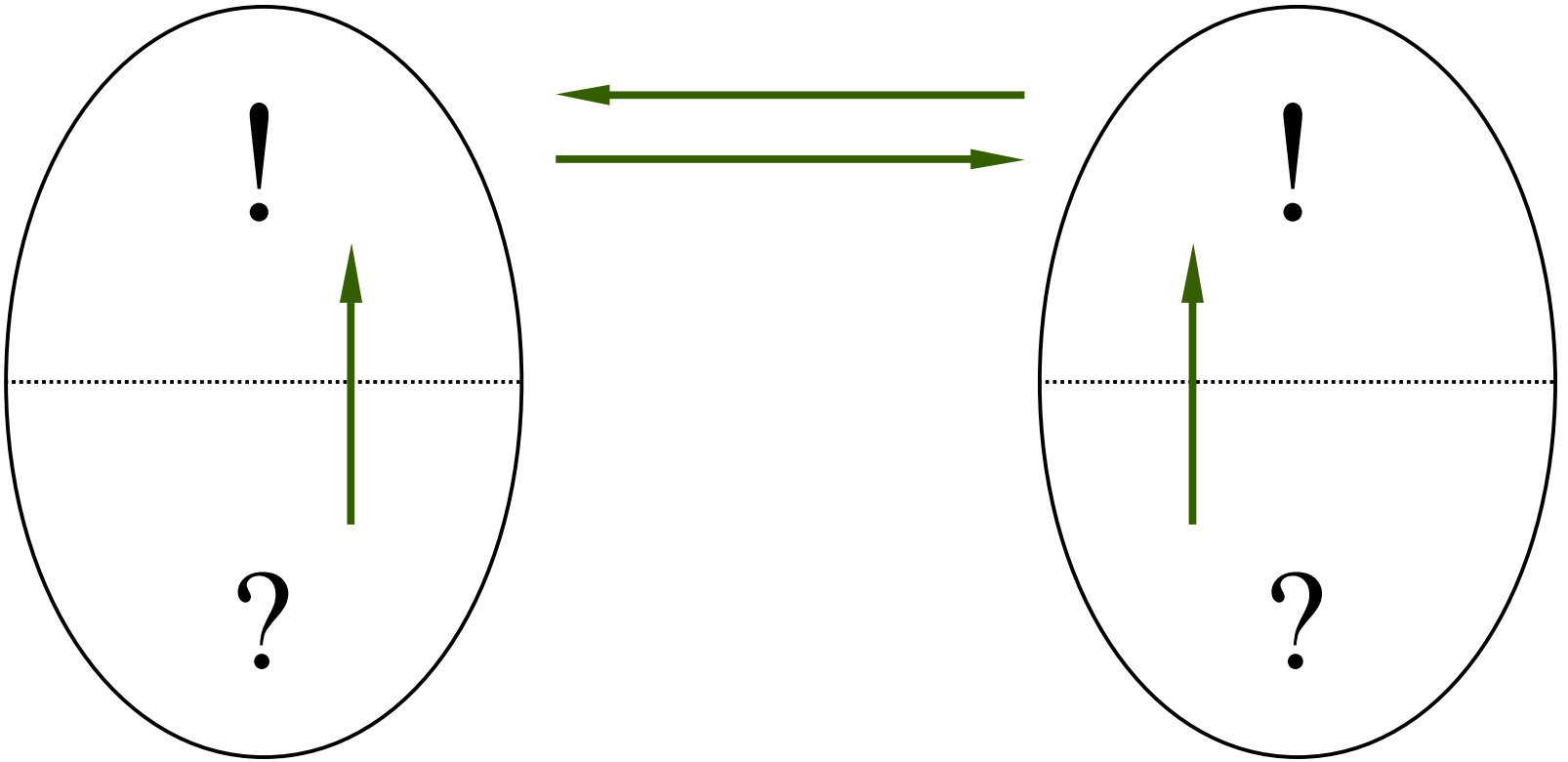
This is all that we normally know, if we don't reflect on what we know.

Usage diagram:



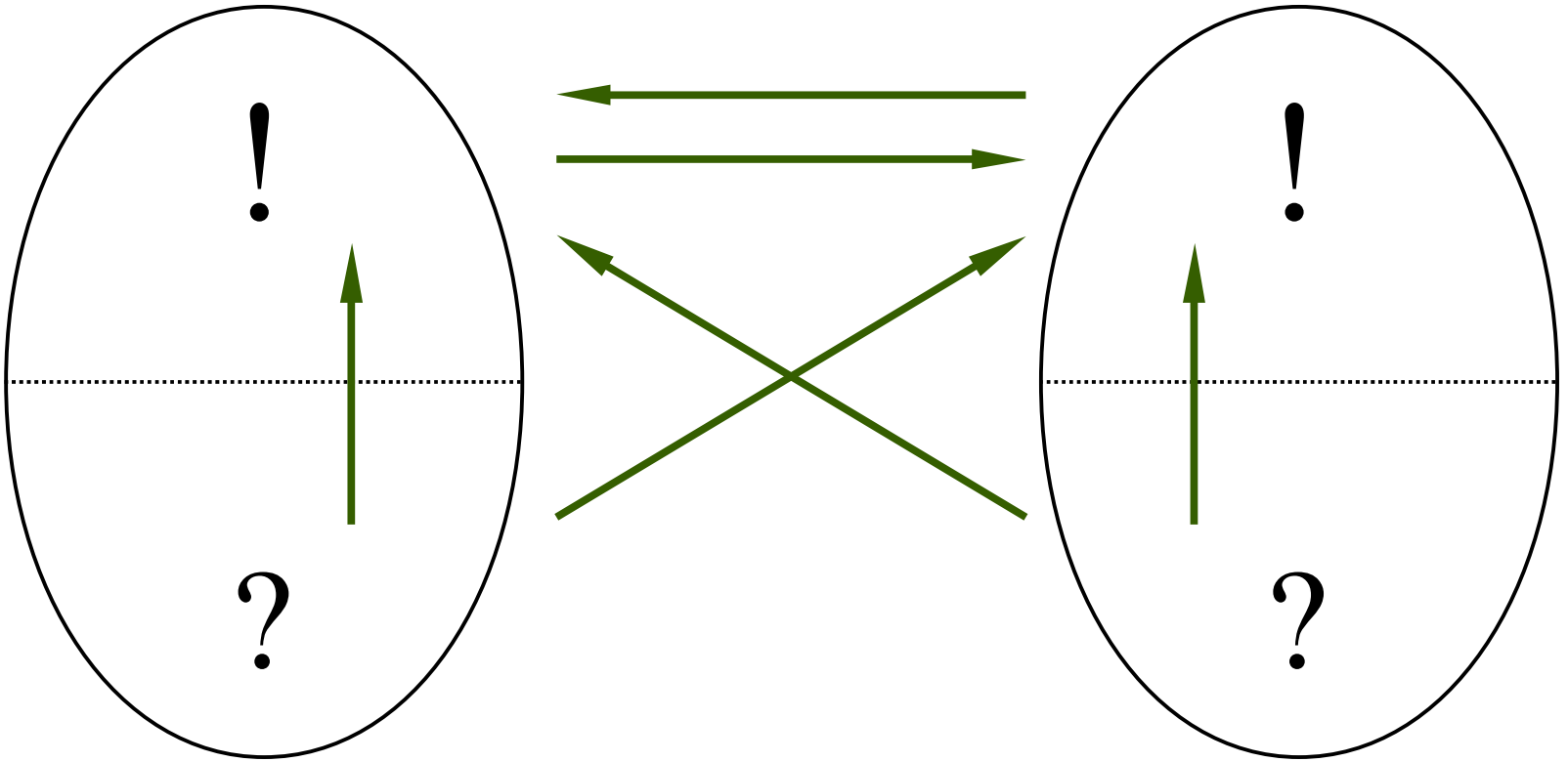
This is all that we normally can use, even without knowing/reflecting.

Internal Knowledge of knowledge diagram:



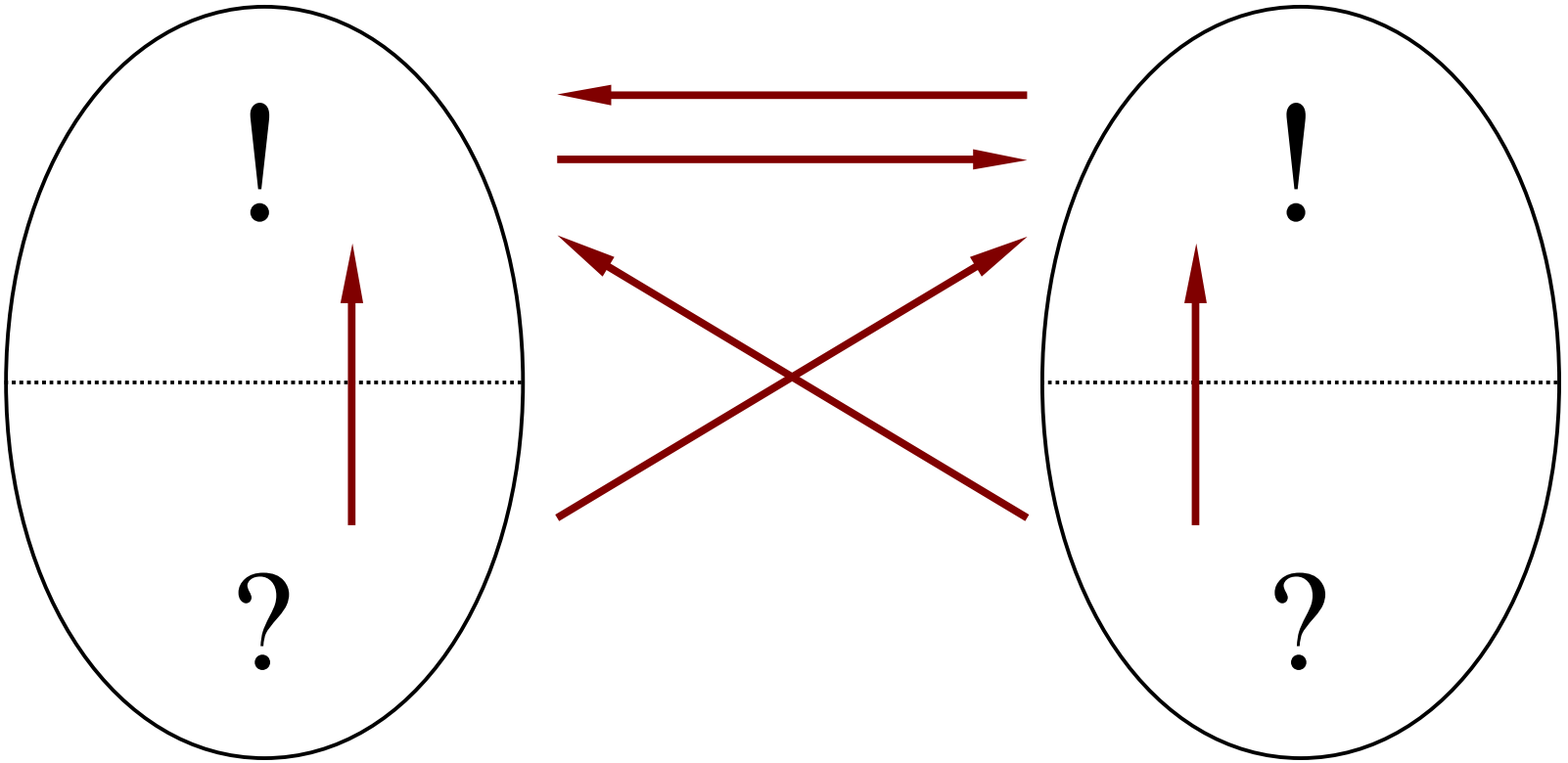
If we learn to reflect, we can begin to know our own tacit knowledge.

Shared Knowledge of knowledge diagram:



And when we know more of what we know, we can share more knowledge.

Usage of Knowledge of knowledge diagram:



And when we can share more, we can then use more knowledge.

To sum up:

- Within a single community, knowledge of knowledge is not required:

    1) just use tacit knowledge, no problems

- Between two different communities, we need several steps:

    1) internal usage of tacit knowledge needs to be made explicit

    2) this knowledge of knowledge needs to be communicated

    3) only then can both sides use tacit knowledge of both sides

Now all of this looks reasonable and logical, but . . . .

. . . . can we really transform tacit knowledge into explicit knowledge?

Let us look again at our first example.

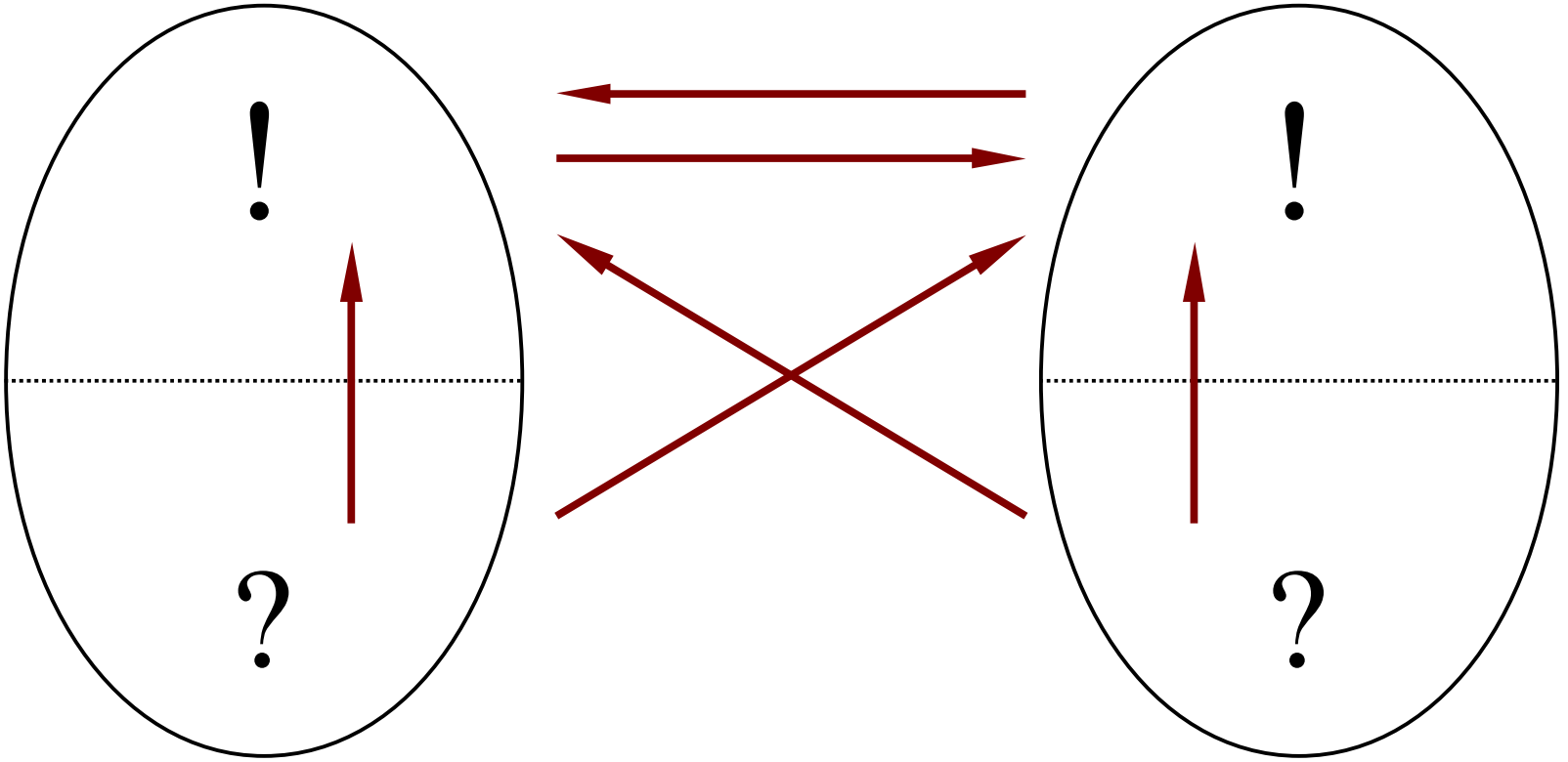
explicit meaning: 暑いですねえ : It is hot, isn't it!

tacit meaning: 暑いですねえ : this can have many different meanings, depending on context: just a friendly sharing of feelings; or a sign to take off your coat and neck tie, to be more informal.

The question is: can we really expect to translate 暑いですねえ into a single formula, a single meaning, something that we can transmit in a single message from one person to another?
Hmmm. . . There may be far too many shades of meaning involved.
Perhaps what we really need is to form a common, shared environment.

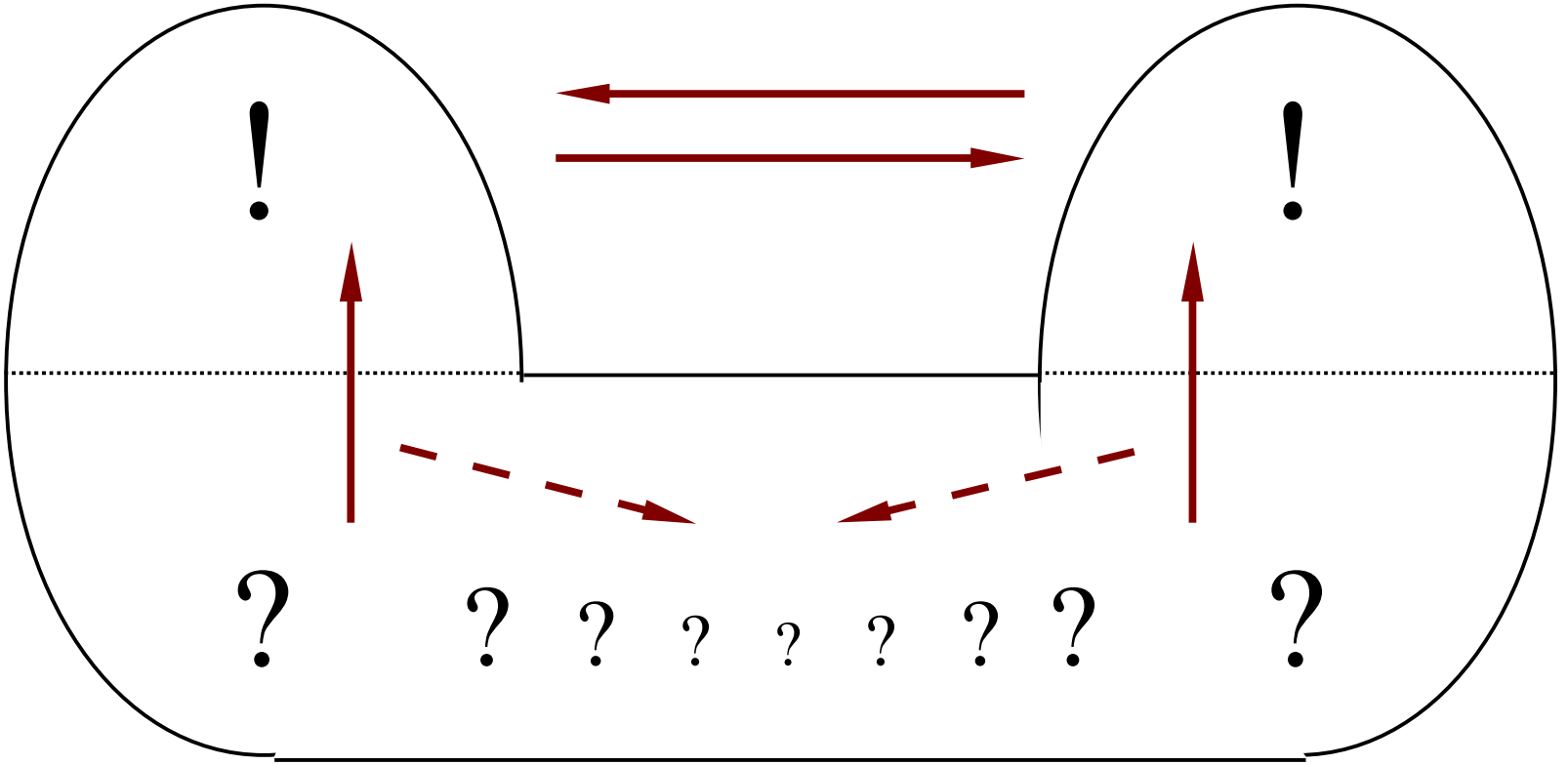
Instead of this usage model, of making implicit knowledge explicit . . . .

Usage of Knowledge of knowledge diagram:



. . . . in fact, the following model may be much more realistic.

Usage of Knowledge of knowledge diagram:



Communication of tacit knowledge by sharing, not by explaining

An example: a collaboration between 8 scientists:

2 astrophysicists, 2 geologists, 4 paleontologists,

from 7 different institutes

review article

Nature **329**, 118 - 126 (10 September 1987); doi:10.1038/329118a0

Comet showers as a cause of mass extinctions

PIET HUT[*], WALTER ALVAREZ[†], WILLIAM P. ELDER[‡], THOR HANSEN[§], ERLE G. KAUFFMAN[‡], GERTA KELLER[||], EUGENE M. SHOEMAKER[¶] & PAUL R. WEISSMAN[£]

[*]The Institute for Advanced Study, Princeton, New Jersey 08540, USA
[†]Department of Geology and Geophysics, University of California, Berkeley, California 94720, USA
[‡]Department of Geological Sciences, University of Colorado, Boulder, Colorado 80309, USA
[§]Department of Geology, Western Washington University, Bellingham, Washington 98225, USA
[||]Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08540, USA
[¶]Branch of Astrogeology, US Geological Survey, Flagstaff, Arizona 86001, USA
[£]Earth and Space Sciences Division, Jet Propulsion Laboratory, Pasadena, California 91109, USA

I was the editor for this 8-author article.
It was the most difficult paper that I have ever edited!
After half a year of trying to write bits and pieces,
with no success, I realized what the problems was:

Even though everybody was very friendly in sharing
what they knew they knew;
they could not share what they didn't know they knew.

In physics, a single experiment can decide whether a theory
is right or wrong.
In paleontology, many observations are needed, and only the
combination of many observational results can make a theory
more plausible, but still not definitely right.
So there is a very important shift in methodology, from
physics to astrophysics to geology to paleontology.

However, each scientist tends to learn only one methodology!

Therefore, after half a year, I invited all my co-authors to come to Princeton for a long weekend.

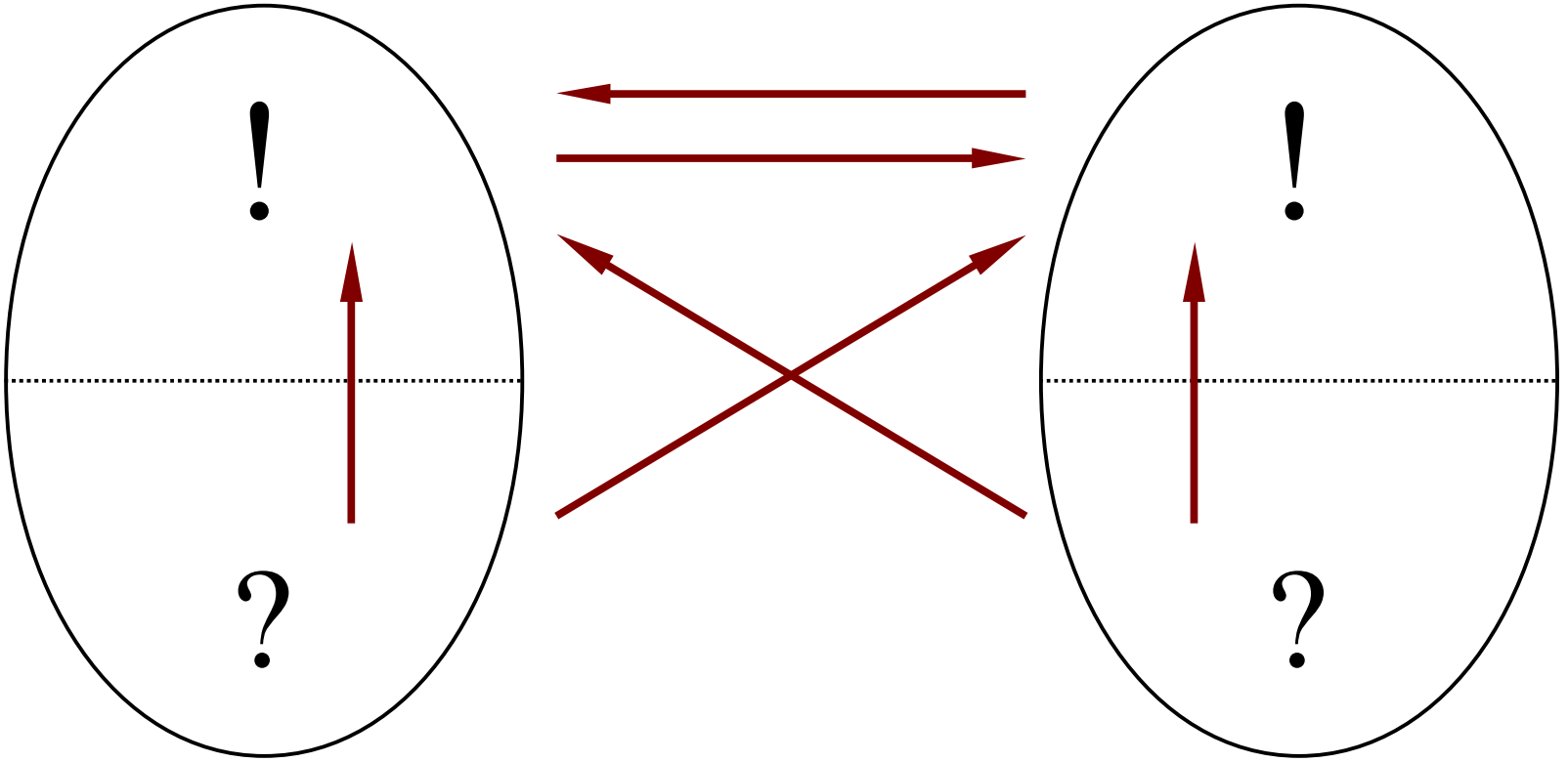
We started on Friday afternoon just talking about our own interests, and then we had a good dinner, with drinks.
On Saturday morning, after we had gotten to know each other better, we started to review why we had so much difficulty understanding each other. Each person explained what he/she did not understand about the reactions of the other.
Only on Sunday did we begin to write again. Soon we could finish the whole paper.

What I learned that weekend was:

> Formal knowledge can be transferred in a formal way,
> but informal, tacit knowledge needs an informal atmosphere,
> a more playful atmosphere, to be transferred by sharing.

Instead of this usage model, of making implicit knowledge explicit . . . .

Usage of Knowledge of knowledge diagram:



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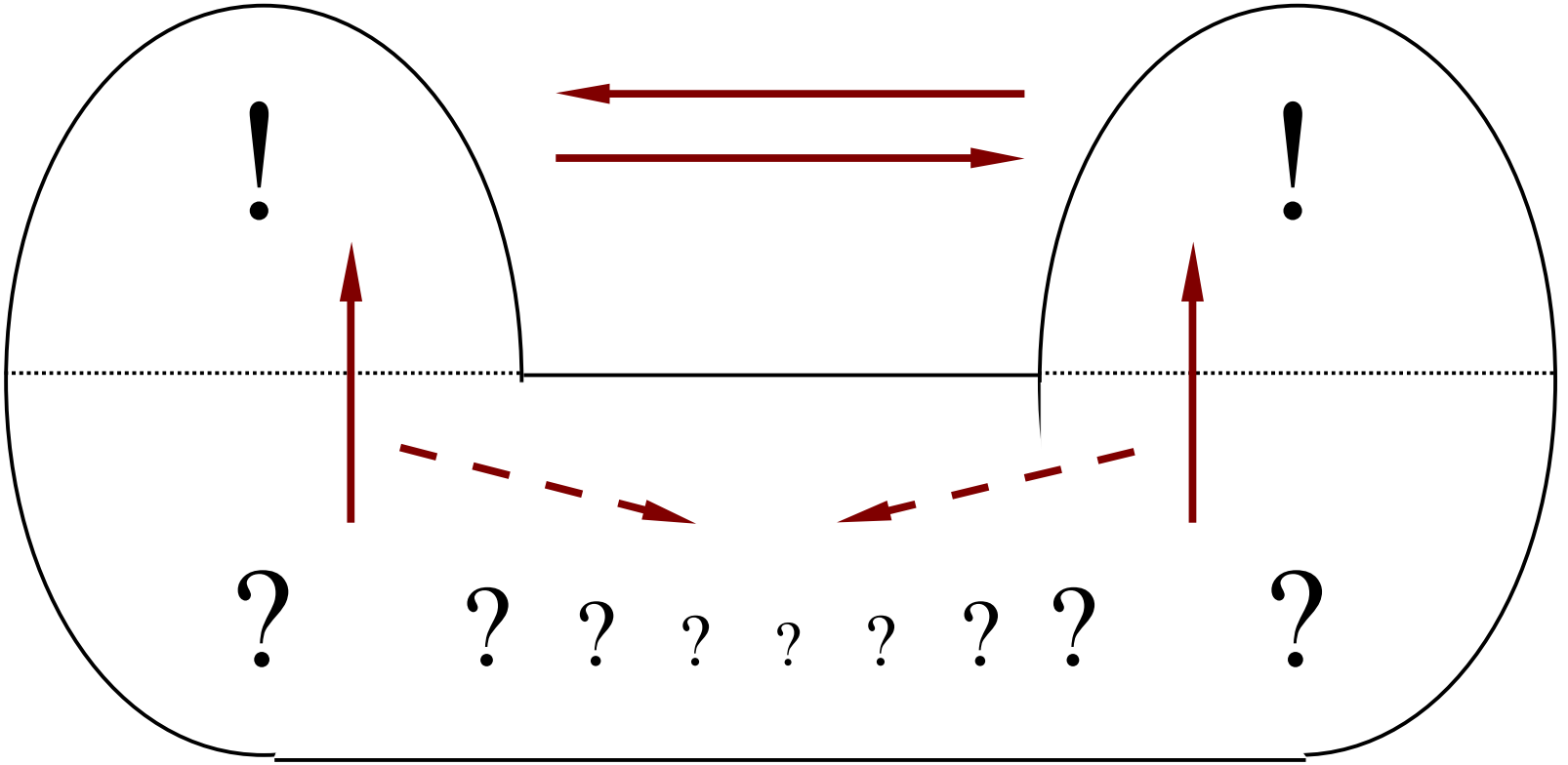


Communication of tacit knowledge by sharing, not by explaining

Conclusion:

Explicit knowledge, written rules, formalized knowledge:
this can be communicated by writing and verbal explanations.

Tacit knowledge, unwritten rules, implicit knowledge:
this can be communicated by sharing in a playful immersion.

Implications:

Research within a discipline can *seem* to be rather formal, because it rests on a shared basis of many years of playful immersion in the same kind of atmosphere . . . but:

Interdisciplinary research needs to start with playful encounters, to create a new basis upon which a shared tacit understanding can be build, from scratch.

Institute for Advanced Study

After Hours Conversations

After Hours Conversations, a program organized by Professor Caroline Bynum of the School of Historical Studies and Professor Piet Hut of the Program in Interdisciplinary Studies, was created to encourage inter-School conversations in an informal and relaxed environment. The events are held three times a week and feature brief talks by Institute Faculty, Members, and Visitors, followed by discussion, drinks, and more conversation. The program commences in October, and the entire Institute community is encouraged to attend as often as you like.

Beginning in October
Mondays, Tuesdays, and Thursdays
5:15–7:00 p.m.

Harry's Bar
located on the top level of the Dining Hall

All beverages, including bottled water, must be purchased with an Institute ID card.

Faculty, Members, Visitors, Staff, Spouses, and Partners Welcome!

If you are interested in giving a talk, please contact Professor Bynum (cwbynum@ias.edu) or Professor Hut (piet@ias.edu).

For more information, please visit
www.ids.ias.edu/conversations0809.html

After Hours Conversations 2011-2012

October - November 2011 ; February - March 2012

After Hours Conversations is a program of informal meetings that are held at Harry's Bar in the upper level of Simons Hall, from 5:00 pm till 7:00 pm, on Mondays and Thursdays, in October and November and again in February and March. The sessions will be moderated by Piet Hut, Program in Interdisciplinary Studies; Nicola Di Cosmo, School of Historical Studies; Didier Fassin, School of Social Science; and Helmut Hofer, School of Mathematics.

The format is as follows. At 5:30 pm, someone will give an informal presentation of no more than 10 minutes, intended for a general audience. The topic will be a brief

Monday, January 30, 2012
Presentation by: Boaz Katz, School of Natural Sciences
Title: *What Does Special Relativity Mean?*
Host: Piet Hut

Thursday, February 2, 2012
Presentation by: Stanislas Leibler, School of Natural Sciences
Title: *Is Biology a 'Narrative Science'?*
Host: Piet Hut

Monday, February 6, 2012
Presentation by: Michael van Walt van Praag, School of Historical Studies
Title: *Unfulfilled Promises: The Failure of the International Legal and Institutional System to Ensure Peace*
Host: Nicola Di Cosmo

Thursday, February 9, 2012
Presentation by: Celeste Arrington, School of Social Science
Title: *Victimhood: When Political Weakness Becomes a Strength*
Host: Didier Fassin

Monday, February 13, 2012
Presentation by: Philip Ording, Program in Interdisciplinary Studies Visitor
Title: *What is Mathematical Style?*
Host: Piet Hut

Thursday, February 16, 2012
Presentation by: Jérémie Barthas, School of Historical Studies
Title: *A Machiavellian Slip: Tenuto/Temuto in The Prince*
Host: Nicola Di Cosmo

Two examples of seminars in the
Program of Interdisciplinary Studies,
by a literature scholar and a mathematician

Ways of (not) knowing:
cartography, art, literature

Monica Manolescu

February 21, 2011

Variations on a Proof

Mathematical Exercises in Style

Philip Ording

February 28, 2012

Ways of (not) knowing: cartography, art, literature

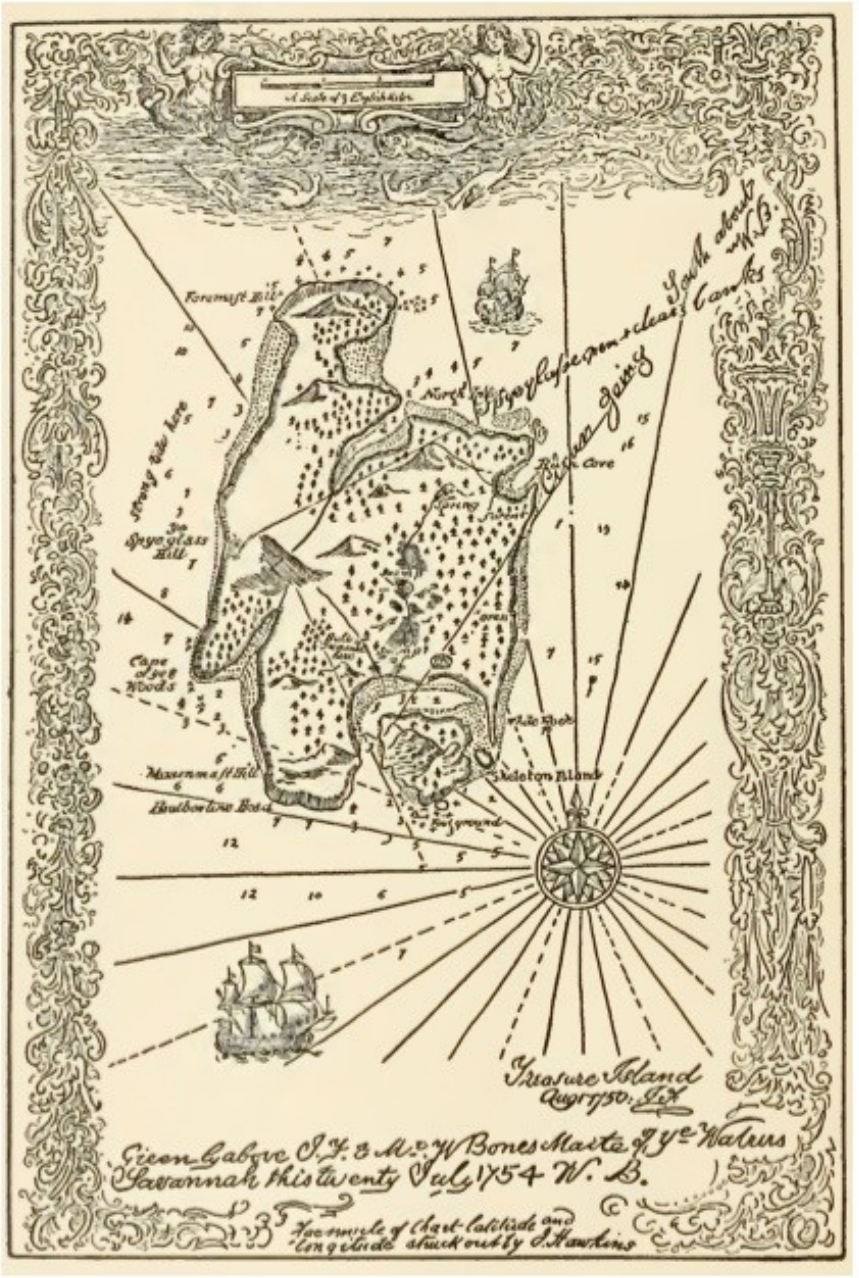
Monica Manolescu

February 21, 2011

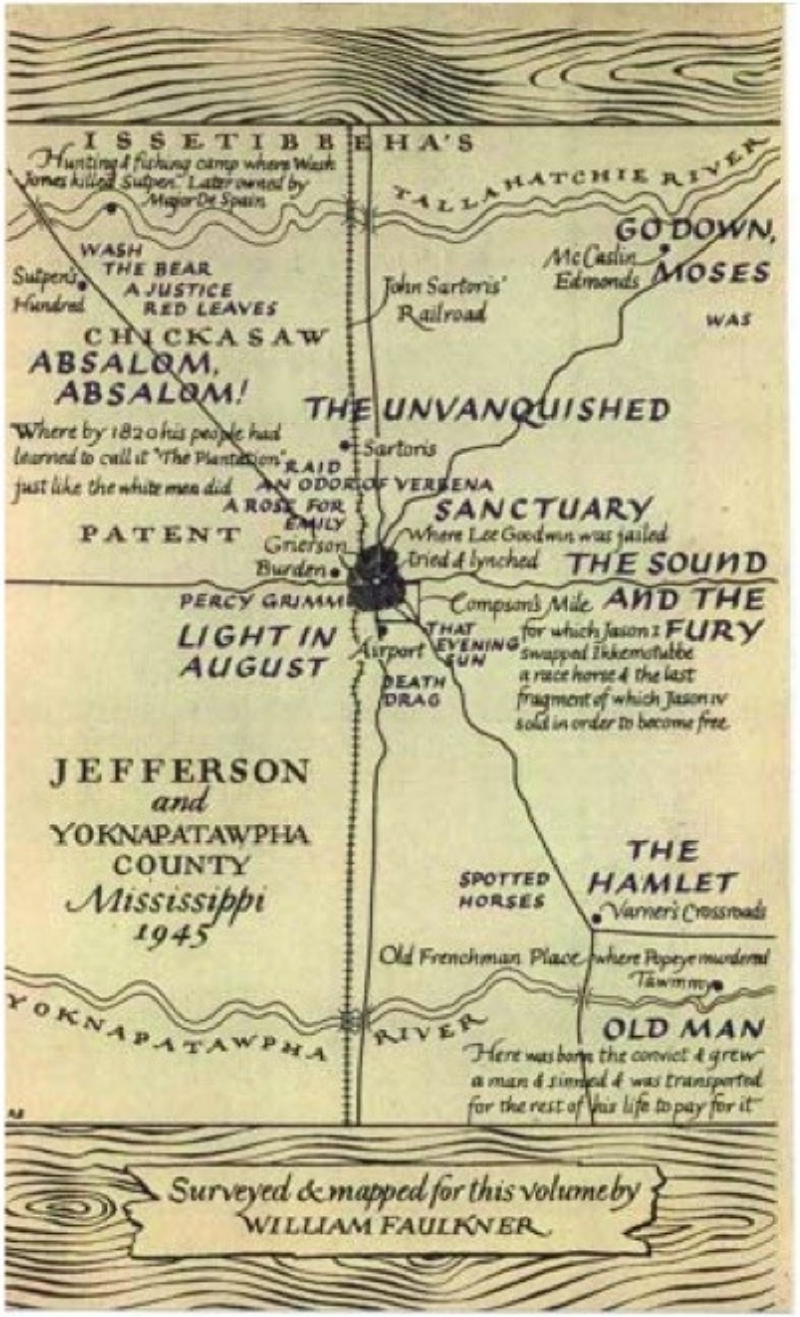
Thomas More, *Utopia* (1516), woodcut from the first edition

Treasure Island, R.L. Stevenson (1883)

1915 Harper edition, illustration by Louis Rhead



Map of Yoknapatawpha county drawn by William Faulkner, First included in *Absalom, Absalom* (1936)



Variations on a Proof

Mathematical Exercises in Style

Philip Ording

February 28, 2012

One Line

Theorem. *Let* $x \in \mathbb{R}$. *If* $x^3 - 6x^2 + 11x - 6 = 2x - 2$, *then* $x = 1$ *or* $x = 4$.

Proof. $x^3-6x^2+11x-6 = 2x-2 \Rightarrow x^3-6x^2+9x-4 = 0 \Rightarrow (x-1)^2(x-4) = 0 \Rightarrow x = 1, 4.$ $\square$

Illustration

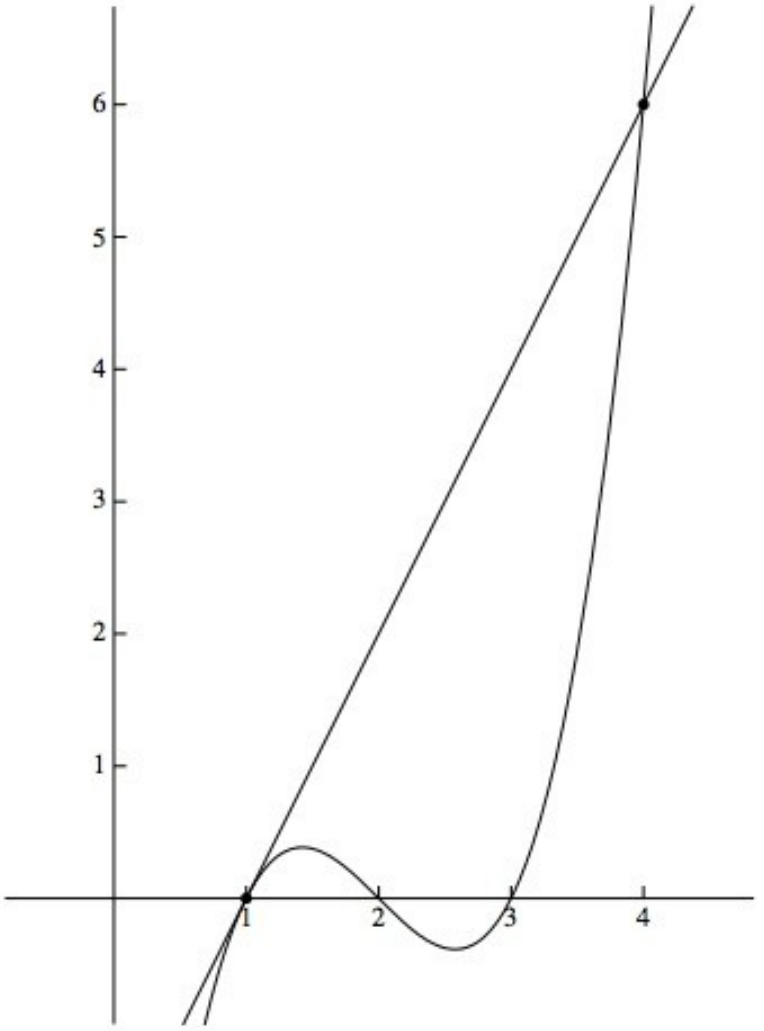


Figure 1. The two points of intersection of the cubic $y = x^3 - 6x^2 + 11x - 6$ and the line $y = 2x - 2$ occur at $(1, 0)$ and $(4, 6)$.

Induction

Theorem. *If n is a natural number and $n^3 - 6n^2 + 11n - 6 = 2n - 2$, then $n = 1$ or $n = 4$.*

Proof. Let $p(n) = n^3 - 6n^2 + 11n - 6$ and $q(n) = 2n - 2$. The claim is easily verified for the first five natural numbers by evaluating the difference $p(n) - q(n)$ for $1 \leq n \leq 5$. For example, $p(5) - q(5) = 24 - 8 = 16$. Assume that for some natural number $m \geq 5$, $p(m) - q(m) > 0$. Then $p(m+1) - q(m+1) = p(m) - q(m) + 3m(m-3) > 3m(m-3)$, by the induction hypothesis. But $3m(m-3) > 0$ since $m \geq 5$, hence $p(n)$ and $q(n)$ are distinct for all n above $n = 5$. □

Renaissance

The cube & 9.quantity equals 6.square & 4. Multiply 6, the number of the square by 2, $\frac{1}{3}$ of itself, making 12, the difference between which and the quantity is 3, and since the product is the greater, as many unknowns will equal the cube. To derive the number for this equation, multiply 9, the number of the quantity by 2, $\frac{1}{3}$ the number of the square, making 18, the difference between which and 20, the sum of twice the cube of $\frac{1}{3}$ the number of the square and 4, is 2. Therefore, since the sum is greater than the product the cube equals 3.unknown & 2, and the unknown will be 2. By adding 2, $\frac{1}{3}$ the number of the square, 4 results as the true solution.[1]

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Title: On a cube and first power equal to a square and number
Authors: Girolamo Cardano
Categories: math.GM
Comments: 4 pages, 1 figure
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There has been important progress toward solving cubic
equations since the pioneering work of Khaayyam. In this
century, a general method for obtaining solutions in the case
of a cube and first power equal to a number was provided
by del Ferro. In the present paper we compute all solutions of
the cubic $x^3+9x=6x^2+4$ by transforming it into a quadratic-
free cubic. There follows a discussion of certain derivative
quartic equations. Additional applications include compound
interest, profit on repeated business trips, and the proper
distribution of monies among soldiers.
\\(http://arxiv.org/abs/4305.1160 , 11kb)