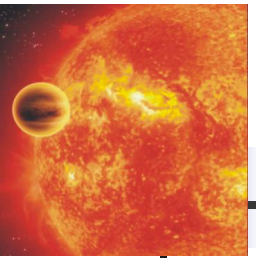
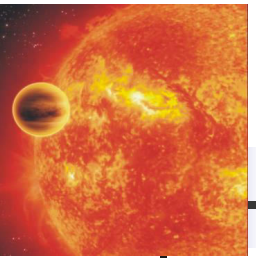
Scientific Revolutions (PH 213) & History of Science (PH 404)

Professor John Worrall



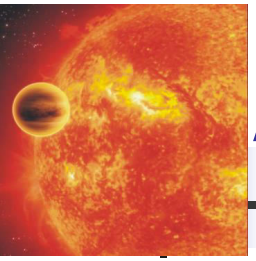
Course Information

- Course leader: John Worrall
- Email: j.worrall@lse.ac.uk
- LAK 3.02 Office hours Mon 13.30-14.30 and Tuesday 10.30-11.30
- **Slides for this course, literature list, readings etc. on Moodle**



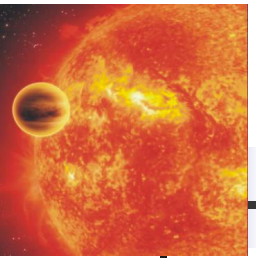
Course Outline

- Philosophical Background: Popper, Kuhn and Lakatos
- The Copernican Revolution
- Galileo and the Telescope
- The Newtonian Revolution (or synthesis?)
- 19th Century "Revolutions" in Optics
- The Darwinian Revolution



Assessment

- **Ph 213**: 3 hour written exam in the summer term
- **Ph404**: 2000 word essay handed in at the beginning of the summer term (33%)
- 2 hour exam summer term (67%)



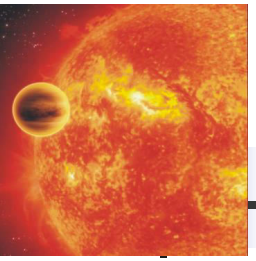
Books Needed

- Kuhn, T. (1957/2003) *The Copernican Revolution*. Harvard University Press.

- Kitcher, P. (1983) *Abusing Science: The Case Against Creationism.* MIT Press.

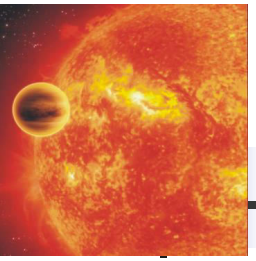
Philosophical Background, Popper, Kuhn and Lakatos

John Worrall



Required Reading

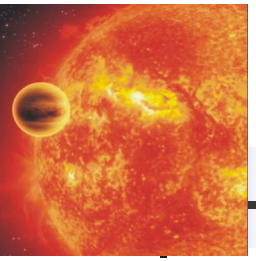
- Popper, K. (1953) Science: Conjectures and Refutation. Good introduction to Popper's ideas
- Kuhn, T. (1963) The Function of Dogma in Scientific Research. Good introduction to Kuhn's ideas
- Lakatos, I. (1987) Falsification and the Methodology of Scientific Research Programmes. Sections 1 – 3b (8-52) and section d (68-73). Good introduction to Lakatos's ideas and good discussion of falsificationism



Further Literature

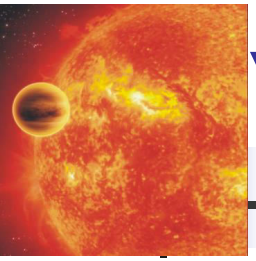
- Lakatos, I. (1973) Science and Pseudoscience. Lakatos's public summary of his philosophy of science; http://www.lse.ac.uk/collections/lakatos/scienceAndPseudoscienceTranscript.htm

- Bird, A. (2004) Thomas Kuhn. Stanford Encyclopaedia of Philosophy. Good Introduction to Kuhn. http://plato.stanford.edu/entries/thomas-kuhn/



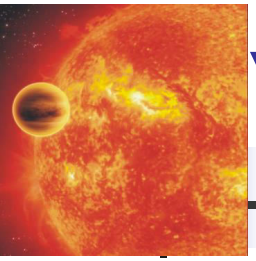
Science versus Pseudoscience

- One great tradition in Western thought – science as the epitome of rationality
- In contrast, pre-scientific man had all sorts of beliefs about spirits, magic, etc.



"Pre-scientific" Beliefs Today

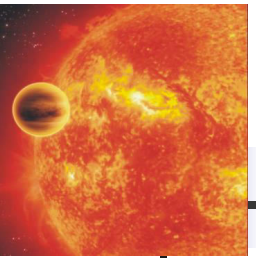
- Indeed, many people nowadays have (sometimes amazing) "pre-scientific" beliefs
- Examples?



"Pre-scientific" Beliefs Today

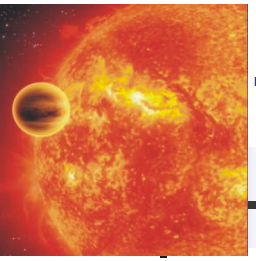
- But: these beliefs have no rational, evidential basis
- They have not been *properly* experimentally tested and accredited

Science as the Epitome of Rationality

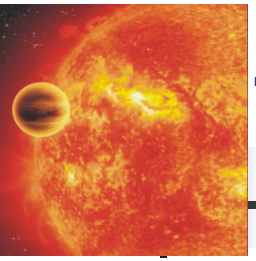


- In science we only accept claims that have been properly tested and accredited
- By sticking to these demands mankind has been able to reject magic and built up an impressive body of truths
- Scientific revolutions lead us to better theories

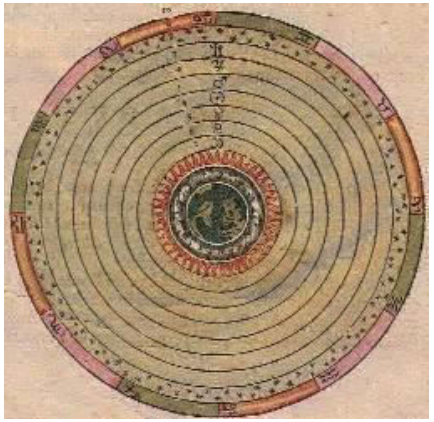
Example: the Copernican Revolution



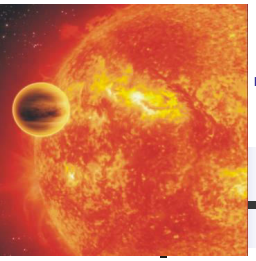
- Take as an example the first episode we will study: the Copernican revolution
- This met with a lot of resistance: witness the treatment of Galileo
- But not just the Church
- The Aristotelian world view was very ‘cosy’



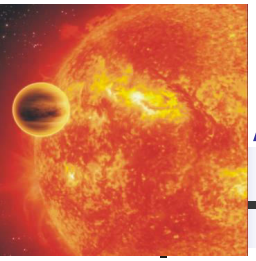
Example: the Copernican Revolution



Example: the Copernican Revolution

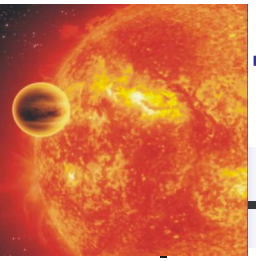


- Yet eventually reason, in the form of scientific method, won out
- Despite the attractions of thinking that our Earth is the centre of the universe the evidence told a different story
- This had enormous impact on man's view of herself



And yet…

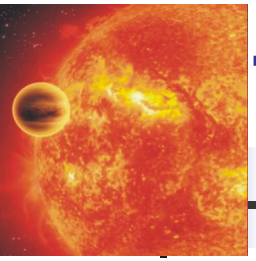
- Recent studies stemming from Kuhn's *Structure of Scientific Revolutions* have challenged this nice rational picture
- And gave rise, in one way or another, to various "postmodernist" views



The Road to Postmodernism

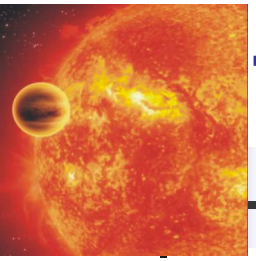
- These studies have focussed especially on *scientific revolutions*
- The fact that science has changed its collective mind so often *and in such radical ways* brings into doubt the whole idea of science as a rational enterprise
- Moreover following Kuhn, many argued that detailed investigation shows that non-rational factors

  influence theory change



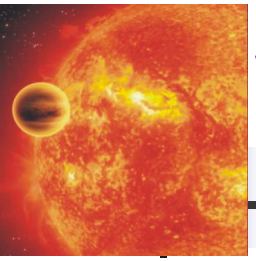
The Road to Postmodernism

- Indeed, they have claimed that the whole idea of science as an essentially rational process dissolves
- Science is one paradigm among many
- The idea that science has special authority is just dogmatic



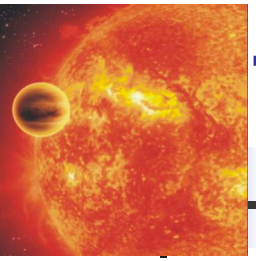
The Main Topic of this Course

- Look at various episodes of major theory changes in science to discuss whether these commentators influenced by Kuhn are right
- Or whether the "old fashioned view" that science is an essentially rational process can still be defended while accepting that significant changes of accepted theory in science have indeed occurred.



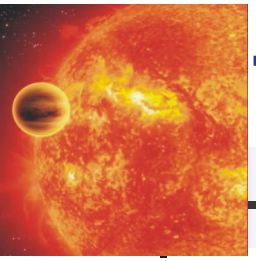
What is Science?

- First of all, we had better get an idea of what constitutes science
- And of what the basis might be for a claim that operating scientificially is the same as operating rationally
- We will review four main views: the inductive view, Popper, Kuhn and Lakatos



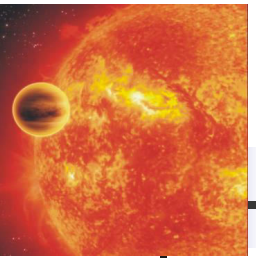
The Inductive View

- Idea 1: Science is
- (i) simply opening one's eyes (and other sense organs), freeing them from prejudice – i.e. observing in a theory-free way and eventually
- (ii) generalising from those neutral observations
- We observe and then we generalise
- For instance, we see lots and lots of ravens and notice that they are all black
- From this we eventually infer that all ravens are black

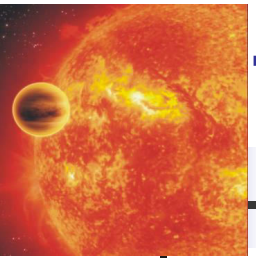


The Inductive View: Problems

- Serious problems with this account.
- 1.How can we justify the generalisation from observations (Hume's problem of induction)?
- Constructive counterexamples: Europeans inferred that all swans are white. But ...

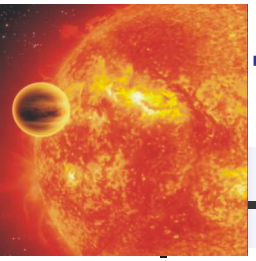



Somewhere Else



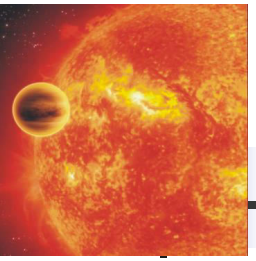
The Inductive View: Problems

- 2. Observe WHAT?
- 3. …how could it possibly work for inferences about neutrinos, quarks, electrons, and all the other wonderful stuff that science tells us about?



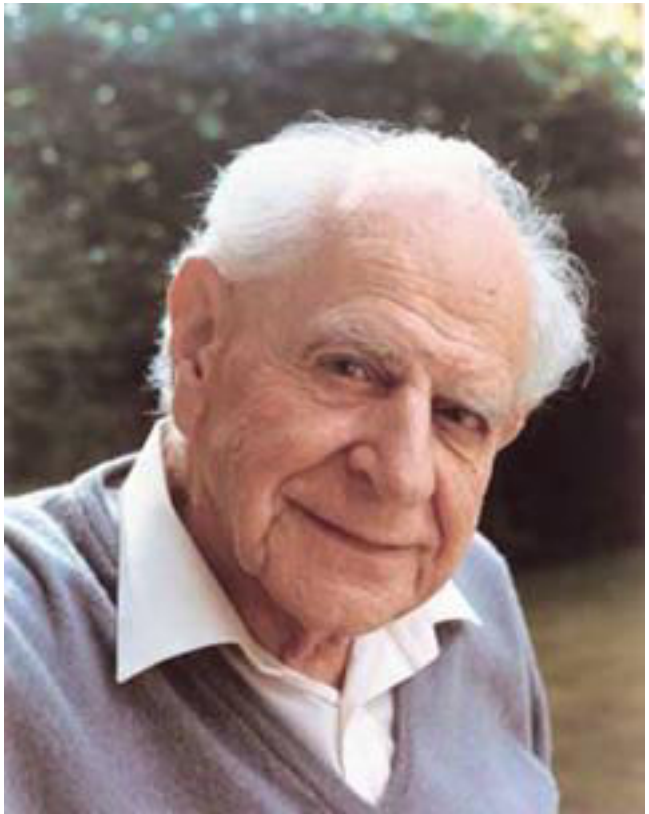
The Inductive View: Problems

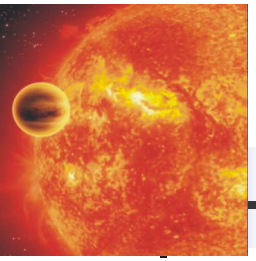
- Electrons are not observable
- So theories such as: “All electrons are negatively charged” could not be based on generalisations of observations



Popper and Falsificationism

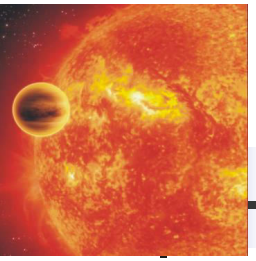
- For these reasons, amongst others, Karl Popper rejected the whole idea of science as an inductive enterprise





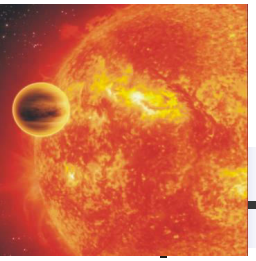
Popper and Falsificationism

- According to Popper, science instead consists of a grand application of the trial and error method
- Scientists make *conjectures* and *test* them



Popper and Falsificationism

- Compared to inductivism, Popper completely reverses the view of the logic of science
- Not from observations *up* by induction to theories
- Rather from theory *down* by deduction to observations

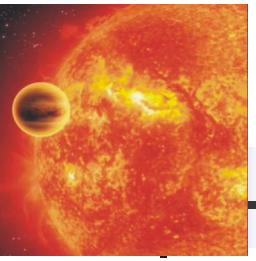


Popper and Falsificationism

- A scientific theory proves its evidential credentials by:

(1) Being highly testable (falsifiable)

(2) Surviving all tests; being highly *corroborated* (having been subject to many tests but not been refuted)



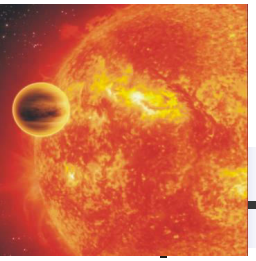
Popper and Falsificationism

- Example: Newton's theory of universal gravitation
- All sorts of predictions about

(i) Motion of planets

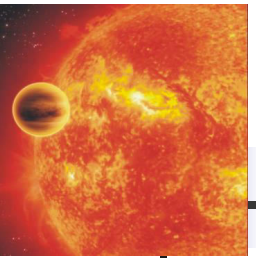
(ii) Return of Halley's comet

(iii) Motion of stars etc.



Popper and Falsificationism

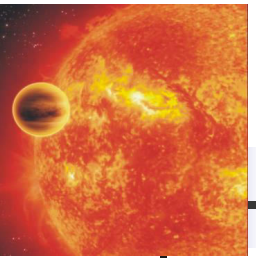
- All turned out to be correct
- Had any of them been not, the theory would have been rejected as false
- Newtonian theory had so many corroborations, that scientists in the 18th and 19th century regarded it as certainly true



Popper and Falsificationism

Alexander Pope:

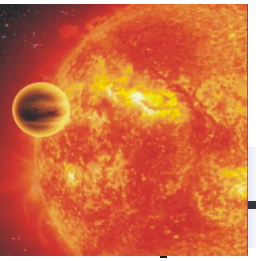
Nature and nature's laws lay hid in Night.
God said, 'Let Newton be!' and all was light.



Popper and Falsificationism

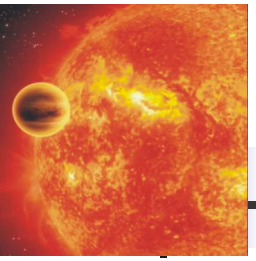
- But they were all wrong…
- According to Popper, this was because Newton's theory was eventually refuted: for example by the observed motion of Mercury's perihelion
- Einstein produced a better theory which passed all the tests that Newton's had passed plus the ones it had failed

Summary of Popper's Falsificationism



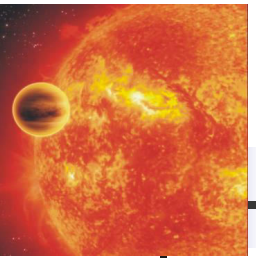
- A theory is scientific iff it is empirically falsifiable
- It is a good theory if it has been corroborated by passing all its tests
- Theory change: when a hitherto too corroborated theory is refuted

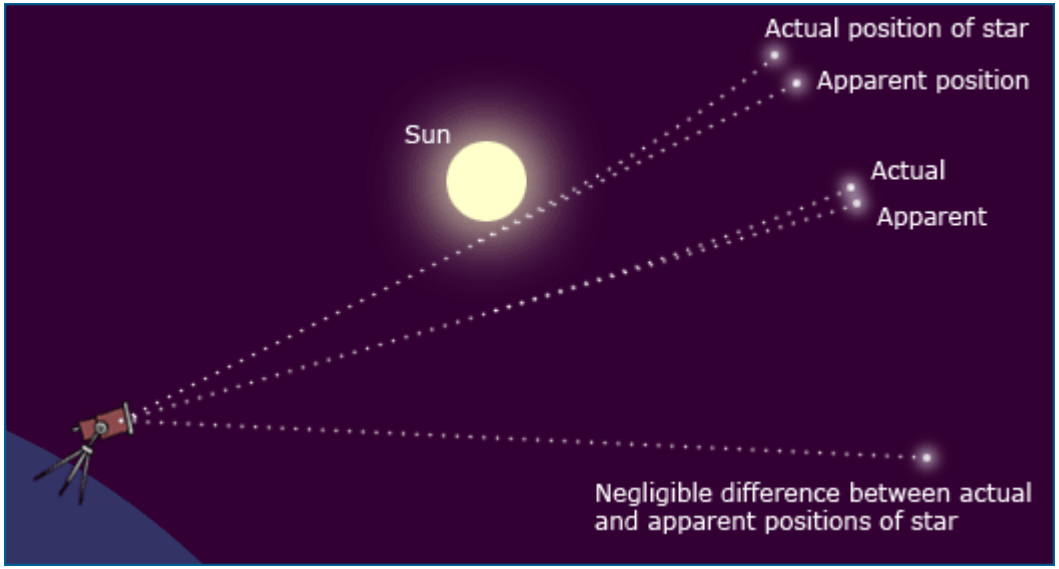
Summary of Popper's Falsificationism

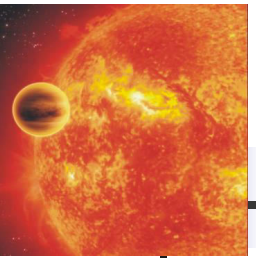


- The refutation may arise independently but more often (cp Gravitational star shift) by a new rival theory being created which contradicts some of the predictions of the older theory
- In either case, once a previously accepted theory is refuted it must be replaced by a new one
- This new one will (must) pass all the tests that its predecessor did *plus* be corroborated by the refutations of that predecessor.

Summary of Popper's Falsificationism

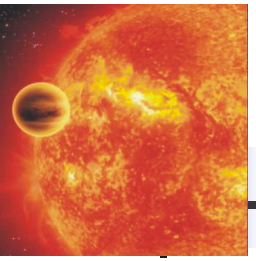






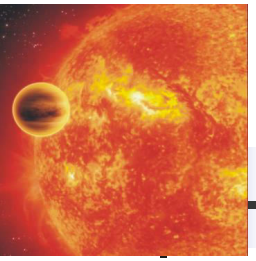
Popper and Pseudo-Science

- This is all in contrast to what Popper saw as the pseudoscientific theories of, e.g., Freud and of Marx
- What counts as pseudoscience for Popper?



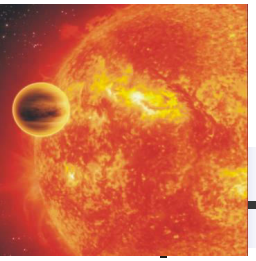
Problems of Falsificationism

- Popper's falsificationism misrepresents scientific practice



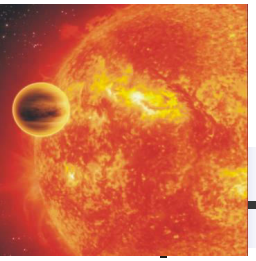
Problems of Falsificationism

- Popper misrepresents the way that scientists react to inconsistencies between what a theory predicts and what is observed
- E.g. Newtonian theory and Uranus.
- Role of auxiliaries

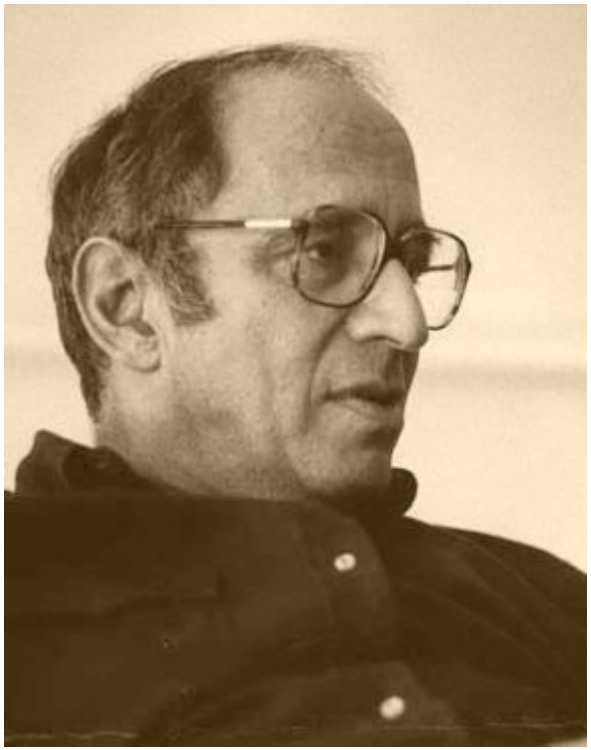


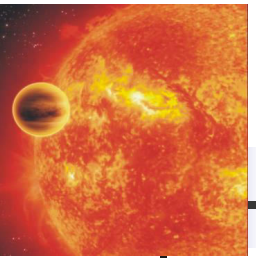
Problems of Falsificationism

- Often there are incorrect predictions which cannot be explained away (at the moment), but theories are not given up
- E.g., although sometimes cited by Popper as a refutation of Newtonian theory, it was known as early as 1859 that the theory's predictions about Mercury's perihelion did not agree with data
- But scientists still accepted Newtonian theory then
- And not clearly irrational of them to do so



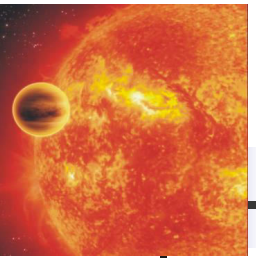
Kuhn’s view





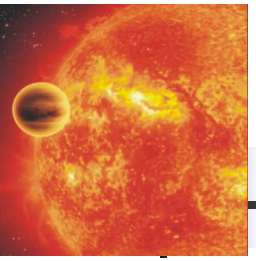
Kuhn's view

- Kuhn saw 'dogma' as playing an important role in science
- Scientists commit themselves to 'paradigms'
- Much bigger unit than simply a theory
- This commitment is not tested by data that 'conflict' with the theory
- Scientists treat these as 'anomalies' and as puzzles requiring resolution within the paradigm
- Cp Newtonian theory and Uranus again



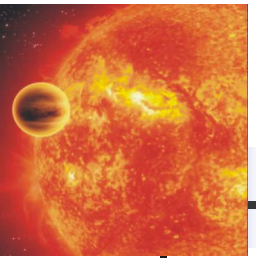
Kuhn's view

- This is 'normal science'
- But how then does theory (or rather paradigm) change (= scientific revolution) occur according to Kuhn?
- Eventually anomalies build up and resist solution within the paradigm
- So that *some* scientists begin to gripped by a feeling of 'crisis'
- However there are no rules for when a crisis should happen



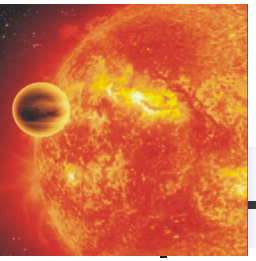
Kuhn's view

- It is just a matter of fact that some scientists feel the crisis and look for a new paradigm
- But others do not and stick with the older paradigm
- There is, for Kuhn, no question of right or wrong
- The process of changing paradigm is 'more like a religious conversion than a scientific proof'
- It is again just a matter of fact that the resisters die out and the new paradigm gains ascendancy
- But this doesn't make it right or rationally justified
- Social factors play a role in the processs and
- 'There is no criterion higher than community assent'



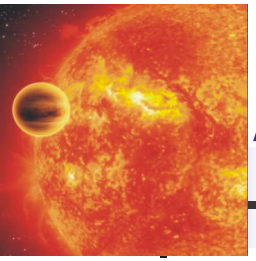
Kuhn's view

- This, plus the facts that paradigms come with
- (i) their own interpretations of the data ('theory-ladenness of observation') and
- (ii) their own methodological standards (in particular for what counts as an adequate solution to an anomaly)
- Means that Kuhn's view certainly threatens the idea that scientific change is rational and
- Seems to leave the door open to relativism



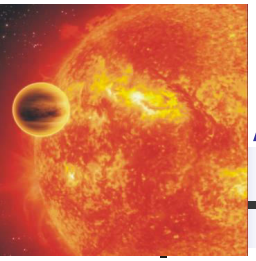
Kuhn's view

- This account surely however cannot be correct
- There is something special about science
- It works!
- And it has worked better and better



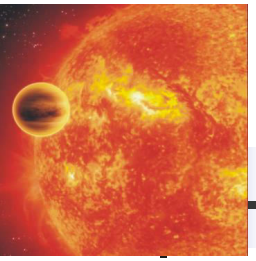
Assessment of Kuhn's view

- So problem:
- 1. Kuhn's picture of science seems in many ways closer to the real thing than Popper's; but
- 2. Threatens to be inconsistent with the specialness of science

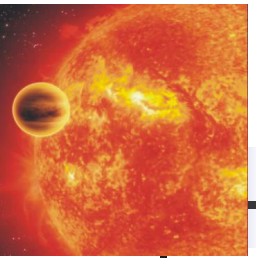


Assessment of Kuhn's view

- That there are no clear initial reasons to adopt a paradigm means that decisions in science are sometimes arbitrary
- There is often more variety of theories in normal science than Kuhn's account allows for



Lakatos's Synthesis

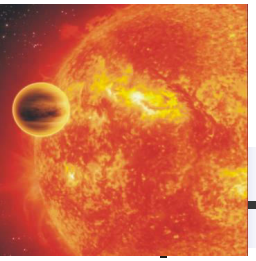


Lakatos's Synthesis

- Lakatos aimed to provide a view that

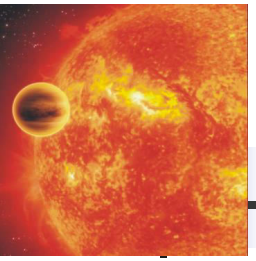
(i) Rescues Popper's rationalist notion of scientific change; while

(ii) Accepting what was right about Kuhn's account



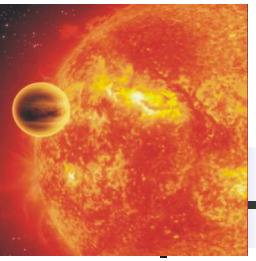
Lakatos's Synthesis

- Scientists seek to protect their theories from anomalies (contra Popper).
- But in some cases this protection is justified (e.g., Uranus anomaly)
- While in other cases it is not justified (e.g., 'Gosse dodge'))



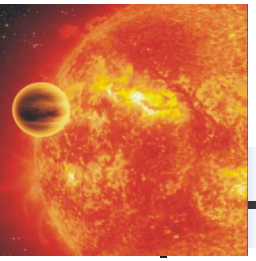
Lakatos's Synthesis

- According to Lakatos, the protection of theories from anomalies is justified if the research programme still *progresses*



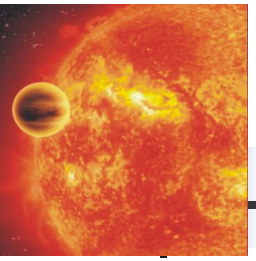
Lakatos's Synthesis

- Kuhn surely right about anomalies
- But if Newtonian reaction to Uranian anomaly was scientifically ok
- What is wrong with Geller's reaction?
- Or the 'Gosse dodge'?
- Lakatos's solution: independent testability
- Difference between a 'degenerating' and a 'progressive problem shift'
- Degenerating iff ad hoc



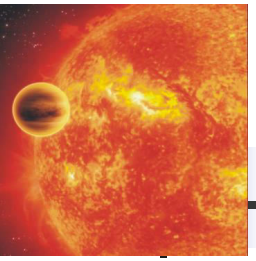
Lakatos's Synthesis

- So science does come in larger chunks than single theories
- Duhem and role of auxiliary assumptions
- Research programmes with 'hard cores' and 'protective belts
- (E.g. wave optics programme)
- Kuhn style reaction to be expected and ok so long as there is *progress*
- The fundamental criterion of independent testability and independent confirmation is not paradigm/programme dependent, but governs the whole of science



Lakatos and Pseudoscience

- What, according to Lakatos, distinguishes science from pseudoscience?



Scientific Revolutions

- In order to get clearer on all these ideas, we need to look how they come up in the context of some real scientific revolutions
- This is what we will be doing!
- We begin with the "daddy of them all": the *Copernican revolution*