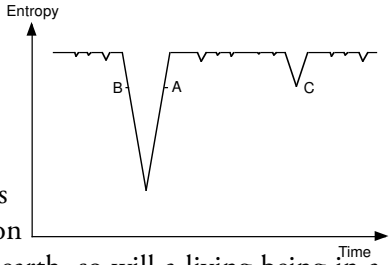

Time – Lecture 3

1 Boltzmann's brilliant idea

"For the universe, the two directions of time are indistinguishable, just as in space there is no up and down. However, just as at a particular place on the earth's surface we call 'down' the direction toward the centre of the earth, so will a living being in a particular time interval of such a single world distinguish the direction of time toward the less probable state from the opposite direction (the former toward the past, the latter toward the future)."

Corollary: No objective direction of time!

• The more basic question: **What would it be** (if anything!) for time to 'have a direction'?

2 "The direction of time is given to us by the Second Law"

• Earman (1974) takes this to be the standard view (at least at the time) – so much so that he calls his challenge to it "The Time Direction Heresy. It states first of all that if it exists, a temporal orientation is an intrinsic feature of spacetime which does not need to be and cannot be reduced to nontemporal features, and secondly that the existence of a temporal orientation does not hinge as crucially on irreversibility as the reductionist would have us believe. I am not at all sure that The Time Direction Heresy is correct, but I am certain that a failure to consider it, if only for purposes of contrast, will only lead to further stagnation."

• Distinguish two versions of this "Reichenbach-Gold" view (as Earman calls it): (i) Weak version: Time *itself* doesn't have a direction (any more than space does), but the entropy gradient accounts for the apparent direction "around here", much as the local gravitational field accounts for our sense of up and down. (ii) Strong version: The direction *of time itself* is reducible to the second law.

• Earman seems to assume that Reichenbach has the strong view in mind (doubtful, imho: R follows Boltzmann), and offers two arguments against it: (a) the entropic arrow could be different in different places (b) it could be absent altogether – i.e. 'no direction of time'. Take these in turn.

2.1 'Orientability'

• The rough idea – continuous transport of an 'arrow pointing to the future'. Does it stay pointing to the future? (Counterexample: a Moebius Strip.) Earman points out that orientability seems necessary though not sufficient for a direction for time. (Why isn't it sufficient? Think of North and South.)

• His first objection to (strong) Reichenbach-Gold: the thermodynamic arrow needn't point the same way everywhere. (Not an objection to the weak version, which doesn't assume that it should.)

2.2 Could time have no direction?

E's second objection to the (strong) Reichenbach-Gold view is that it implies that if, as is surely possible, a universe had *no* thermodynamic asymmetry, it would have no direction of time at all. Like Maudlin (who thinks that there must be a fact of the matter about whether a particular asteroid is *really* moving from Earth to Mars or vice versa), Earman seems to think that this is unacceptable.

• "The radical view that … there could be no temporal orientation, is a view which can also be discussed in Reichenbach's writings. … [However,] I think the implausibility of [this] position should be apparent from several considerations. First, a characterization of invariance under charge conjugation **C** and mirror image reflection **P** can be given along the same lines as given above for **T** invariance. If then the Reichenbach–Gold position is correct for **T**, why isn't it also correct for **C** and **P**?" (E says that the option of accepting that it is the same for **C** and **P** "would seem to involve a great heroism"!)

2.3 Kant's left hand

"[I]magine that the first created thing was a human hand. That [hand] would have to be either a right hand or a left hand. The action of the creative cause in producing the one would have of necessity to be different from the action of the creative cause in producing the counterpart."

• Kant's claim is that if God wants to make a one-hand world, He has to choose whether he makes it a one left hand world, or a one right hand world. Similarly – this is Earman's point – if He wants to make a world with a Big Bang type singularity at just one end, He has to decide whether to put it at the beginning or the end (not the same thing as which the inhabitants regard as the beginning of the end!). But is this so, in either case?

• Tempting to put the issue in terms of numbers of possible worlds: are there two possible one-hand worlds, or only one? (Similarly for the temporal case.) But we need to be careful: there might be two possible one hand worlds because hands have some *other* property – e.g., +ve or -ve 'charm' – such that God needs to choose which kind of charmed hand to make, though there's no L/R choice to make.

• So the issue in the case of the direction of time is this one: *What kind of feature* of the universe forces God to make a choice that it is appropriate to characterise as that between putting the Big Bang at the 'start' rather than the 'end' of time?

3 A direction of time – what would it take?

1. A *de facto* asymmetry of things *in* time? This won't do, because it leaves the *'open question':* Which way does this 'arrow' really point? (This is just like 'Is the Big Bang really at the beginning or the end of time?' – we are looking for something that 'answers that question'!)

2. A T-asymmetry in the laws of physics? Many people (e.g., Horwich, Maudlin) think that finding a T-asymmetry in the laws of fundamental physics would support the idea that time has a direction. Maudlin (2002, 267): "The discovery that physical processes are not, in *any* sense, indifferent to the direction of time is important and well known: it is the discovery of the violation of so-called CP invariance, as observed in the decay of the neutral K meson. These decays are *not* invariant if one changes a right-handed for a left-handed spatial orientation (parity) and changes positive for negative charge (charge conjugation). According to the CPT theorem, any plausible quantum theory will be invariant under parity-plus-charge-conjugation-plus-time- reversal, so the violation of CP implies a violation of T." But we still have the **open question**: When God put in this 'mesonic' arrow, did He make it point 'forwards' or 'backwards', with respect to the real direction of time? And what did He have to *do,* to make that difference? (And how could we tell which choice he made!?)

3. An 'anisotropy' (i.e., an asymmetry) *in time itself?* Time itself might be different in one direction than the other; e.g., finite in one direction and infinite in the other. But again we have the open question: Is the finite end *really* the beginning or the end? What makes one answer the *right* answer?

3.1 Defeating the open question?

• The open question issue stemmed from the fact that for all the candidate 'arrows' we've mentioned, it seemed to make sense – assuming that there is a real 'direction' to time at all – to imagine that the arrow might point in either direction with respect to it.

• To avoid this problem, we need to find an asymmetry that can be argued to be *constitutive* of the (real) difference between past and future. (If it *constitutes* the past–future arrow, then even God doesn't have the freedom to make it point backwards with respect to the past–future arrow!)

• Three candidates: (i) entropy (via idea that 'what *past* means is the direction in which we remember things'); (ii) the direction of causation; and (iii) some asymmetry accessible in conscious experience.

3.1.1 Entropy

We've already seen the problems with this suggestion. The entropy gradient doesn't seem (necessarily) unique enough, or global enough, or necessary enough, to provide a fundamental direction to time.

3.1.2 Causation

• A popular idea, e.g., Mellor 2009: "In this 2009 paper I argue that whatever gives time its direction must be intrinsic, universal, apply at each spacetime point, and lack a spatial counterpart. I then show that these criteria are met neither by the apparent flow of times and events from future to present to past nor by most so-called 'arrows' of time, i.e. temporal processes that always or usually only go one way. I then argue that the direction of causation does meet the criteria and is what distinguishes time from space and gives it its direction."

• Problems. What *is* the direction of causation? What distinguishes causes from effects, and what guarantees that the cause–effect 'arrow' typically points past–future? (And how can we tell?)

• Several possible answers: (i) 'Conventionalism' – part of what we mean by 'cause' and 'effect' is that causes are earlier than their effects. But then the causal arrow can't explain the temporal arrow! (ii) Causal arrow reducible to something asymmetric in the physical world, e.g. entropy gradient – but then we are back to the previous proposal, with all its problems. (iii) Something non-physical and fundamental – but then how do we know about it, and know which way it points? (iv) Something uniquely accessible to consciousness – too spooky for most, and in any case takes us to the next option.

3.1.3 Consciousness

• Eddington: "The view here advocated is tantamount to an admission that consciousness, looking out through a private door, can learn by direct insight an underlying character of the world which physical measurements do not betray. … [Even though] the physicist … does not look kindly on private doors, through which all forms of superstitious fancy might enter unchecked."

• Problems: (i) Tension with physicalism. (ii) Requires that minds could not exist in the other temporal direction, even in regions with opposite entropy gradient. Maudlin *versus* Williams and Price.