Initial Conditions and the ‘Open Systems’ Argument against Laws of Nature

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This article attacks "open systems" arguments that because constant conjunctions are not generally observed in the real world of open systems we should be highly skeptical that universal laws exist. This work differs from other critiques of open system arguments against laws of nature by not focusing on laws themselves, but rather on the inference from open systems. We argue that open system arguments fail for two related reasons; 1) because they cannot account for the "systems" central to their argument (nor the implied systems labeled "exogenous factors" in relation to the system of interest) and 2) they are nomocentric, fixated on laws while ignoring initial and antecedent conditions that are *able to account for systems and exogenous factors within a fundamentalist framework.*

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1. Introduction. This article attacks the argument that because universal laws are not generally observed in the real world of open systems we should be highly skeptical of their universality. This argument is especially associated with Nancy Cartwright, who has branded the belief in universal laws of nature as "fundamentalist" and whose work especially has attracted numerous counterarguments (e.g., Kline and Matheson 1986, Poland 1994, Anderson 2001, Sklar 2003, Spurrett

2001, Hoefer 2003, Psillos 2006. For the sake of brevity we will focus primarily on Cartwright's work). However, her arguments have been resilient; in a 1999 article Earman and Roberts even profess that they "do not know how to begin to assess Cartwright's claim about context-specific factors that in principle elude theoretical treatment" (456). Crucially, however, most of the critiques of open system arguments (including more recent critiques) are focused on laws themselves in one way or another.[1] We find these attacks limited in their effectiveness; while they do support a faith in "fundamentalism," they do not strike at the root of the open system argument. This article differs from other critiques by not focusing on laws themselves, but rather on the inference from open systems to anti-fundamentalism and the importance of initial conditions to this inference.[2]

"Anti-fundamentalists" or "open-systemists" argue that because in the real world all systems are ultimately open, we simply do not see constant conjunction laws of nature operate, and in experiments where we temporarily see constant conjunctions it is only because of human

[1] Other critiques also focus on the inference by many open-systemists from anti-fundamentalism to "natures," "tendencies," or "capacities," which we do not discuss here. If correct, our argument preempts this inference.

[2] Some of the points briefly raised in Earman, Roberts, and Smith 2002 come closest to our argument. They criticize Lange 1993, who presents an argument on 'provisos' similar to the position of Cartwright, for inattention to boundary conditions (Earman, Roberts, and Smith 2002, 284) and argue that Cartwright confuses laws and differential equations of motion while neglecting initial conditions (286 and endnote 5). Otherwise, to our knowledge there has been little sustained attention to the importance of initial conditions to the open system argument. Bhaskar 1975 does discuss initial conditions towards its conclusion (236-237), however, by that point the discussion is entirely within terms of his 'transcendental realist' argument. Cartwright mentions initial conditions in scattered remarks; again we find no passage that clearly addresses our concerns. A point similar to part of our argument on systems is made by Ruphy (2003), particularly when she asks Cartwright how theoretical domains are to be divided into "bits and pieces" (61).

engineered closed systems or "nomological machines." This argument seems motivated by what open-systemists more generally perceive as an ill-conceived attempt to explain our complex world with simple universal laws.

The obvious response to the open system argument is that in open systems we are seeing the effects of exogenous factors. We control for these in our engineered closed systems precisely so we can see laws without interference. In the real world, we can then combine the various laws to account for what we really do observe.

Open system arguments generally reject this approach on the grounds that it is caught in the twin horns of a dilemma. The first horn is that there is no principled way from within a theory to know what to control for to get a law – we would in effect need more general laws or theories to justify the external conditions we impose on an experiment for it to create constant conjunction outcomes. For example, Cartwright states "My conclusion … is that we need to add to the basic 'equations of motion', like F=ma or Schrödinger's equation, a special constraining condition: The equation holds so long as everything that can affect the targeted effect is describable *in the theory*" (Cartwright 2002a, 432-433; emphasis added. See also Bhaskar 1975, 12-13) and:

> All that is law-like on the Humean picture are associations between measurable quantities. That's it. The only way a condition could restrict the range of an association in a principled or nomological way would be via a more complex law…The effect of this is to move the conditioning factor C inside the scope of the law… (Cartwright 1999, 138)

As Cartwright continues, it is clear that she is saying that the irregularities we see in the real world must, for the fundamentalist, somehow be subsumed under more general laws: The "account of laws as regularities goes naturally with a covering law theory of prediction and explanation. One set of regularities – the more concrete or phenomenological – is explained by deducing them from another set of regularities – the more general and fundamental" (Cartwright 1999, 138).

The second horn of the dilemma, because of its obvious nature more often implied that stated, is that the idea that there can be regularities explaining regularities in an infinite regress ("turtles all the way down") is illogical. For example, Cartwright states that "As I urged in chapter 4, the alternative theory of explanation in terms of natures rejects the covering law account. *You can not have regularities 'all the way down'*" (Cartwright 1999, 138; emphasis added).

2. Cartwright's "St. Stephen's Square" Example. The way in which open-systemists depict the "fundamentalist" as needing to subsume deviances from universal laws under more general laws (such as Galileo's constant acceleration and Kepler's imperfect ellipses subsumed under Newton's laws)[3] is especially clear in Cartwright's "St. Stephen's Square" example. This is one of the simplest examples Cartwright uses to illustrate her ideas, based on an example by Neurath of a thousand dollar bill falling in Vienna's Saint Stephen's Square on a windy day. (Due to its relative clarity Cartwright's commitments are particularly evident in this example, which is likely why it is frequently used against Cartwright e.g., in Spurrett 1999, Smith 2001, and Hoefer 2003, although for somewhat different reasons than here.) We consider this example in some detail to make clear Cartwright's depiction of fundamentalist explanation and its flaws.

Unlike a compact sphere in a vacuum, which will follow Newton's second law (gravity providing the force), it is impossible to know how the banknote will fall on a windy day. In the words of Hoefer:

[3] Other examples include the unification of Charles' law and Boyle's law under the Ideal Gas law and Maxwell's unification of theories of electro-magnetism and optics.

> Does this falsify [Newton's] second law? Of course not, says the fundamentalist: the bill's deviation from a free-fall trajectory is explained by *other forces* on it (the wind and air resistance). But where, asks Cartwright, *in physics* does one get the wind forces from? The answer is: nowhere, because physics tells us practically nothing about wind or how it affects floppy paper objects. (Hoefer 2003, 1406)

Cartwright rejects a faith in a universal law of nature, F=ma, because in the real world we observe something other than F=ma. Crucially, she depicts the fundamentalist as believing there is a need for the path of the banknote to be described entirely by laws of physics. Her view is summarized by Hoefer:

> To hold that the second law is true in this case, you have to assume on faith that if one back-calculates the forces necessary to produce the motions of the bill correctly, assuming the second law and subtracting the force of gravity, then (a) the forces you calculate really did exist, on the bill, as it fluttered around; and (b) *those forces are in principle derivable from other fundamental physical laws (QM, perhaps)*. This is an awfully big thing to take on faith, Cartwright thinks. (Hoefer 2003, 1406; emphasis added)

In the words of Cartwright:

> Many will continue to feel that the wind and other exogenous factors must produce a force…That view begs the question. When we have a good-fitting molecular model for the wind, and we have in our theory (either by composition from old principles or by the admission of new principles) systematic rules that assign force functions to the models, and the force functions

> assigned predict exactly the right motions, then we will have good scientific reason to maintain that the wind operates via a force. Otherwise the assumption is another expression of fundamentalist faith. (Cartwright 1999, 28)

This idea that we explain through subsuming deviations from laws under more general laws is not unique to Cartwright, indeed it is widespread. According to Halonen and Hintikka, "It seems to be generally believed among philosophers that to explain something is to subsume it under a generalization" (2005, 57).

If, however, we restate the open system argument in different language, it seems peculiar. Consider the banknote example again. We have an explanandum: Why is the banknote falling as it is, rather than following Newton's Second Law, F=ma? (Or to recast it in predictive terms: Where will the banknote land in St. Stephen's Square?) An explanans of F=ma is rejected by Cartwright, as Hoefer emphasizes, because we have no way within the laws of physics to account for the wind as a force as stressed in Cartwright's quote (1999, 28) above; the problem is posed as a problem of the composition of forces.

But why should the wind be a *force* to be part of our explanation? 'Air' – i.e. atoms of nitrogen, oxygen, argon etc. – does seem to behave according to something like laws of nature (e.g., gas laws). But 'wind' – i.e. variations in the real-world temperatures and pressures and thus flow of masses of air – is a *condition of spatiotemporal irregularities in a particular part of the universe*. The question of "wind" is *not* one of laws, but of how such irregularities in the Earth's air came to be.

Crucially, this is where initial conditions play an indispensable but frequently ignored role. As we will show below, they are crucial for understanding where the irregularities of the universe come from. Irregularities, in turn, are crucial to the concept of "system," compelling both the anthropocentric idealization of "systems" (such as a banknote falling in a city plaza) and their arbitrarily demarcated "exogenous" factors (such as separating the "wind" from the "system" of a city square). Our position boils down to the argument that through using laws *with initial conditions* we can in essence "explain the wind" (that is, we can account for the irregularities in the universe) which is in turn tantamount to explaining what humans perceive of as systems and their exogenous factors. We will first consider in the next section how initial and antecedent conditions account for the irregularities in the universe. In Section 4 we then discuss how irregularities account for what humans perceive as 'exogenous factors' and "systems."

3. Explaining the Wind: Initial Conditions and Irregularities in the Universe. Even to the most ardent supporters of universal laws of nature, such as proponents of the deductive-nomological (DN) model of explanation, it is clear that laws are at most only one part of any explanation, with initial or boundary conditions their vital counterpart. As Earman and Mosterin note, "[a]s far as we are aware, despite all the criticism that has been heaped on Hempel's DN model, no philosopher has criticized it on grounds that it gives prominence to initial conditions" (1999, 20n). The problem, which we believe in part has led to the acceptance of (or at least the failure to reject) open-system arguments, is not that initial conditions have not been *criticized* in discussions of explanation, but that they have received so little attention at all.

Extended discussions of laws far outnumber extended discussions of initial conditions or the related concepts of antecedent and boundary conditions. A search in the *Philosopher's Index* (1940-2005) for entries with the term "laws of nature" in the title finds 124, against only two with the term "initial conditions," a ratio of over sixty to one. If we add the terms "laws of physics" on the one hand, and "antecedent conditions" and "boundary conditions" on the other, and include both the singular and plural forms, the ratio is still 209:4 for titles and

562:103 for abstracts.[4] Wilson (1991), discussing boundary conditions, summarizes his view of the level of attention to initial conditions vis-à-vis laws: "[T]he standard philosophy text says virtually nothing about boundary conditions – they are scarcely mentioned before they are packed off in an undifferentiated crate labeled 'initial and boundary conditions' (usually pronounced as one word). The salient fact about 'initialandboundaryconditions' is that, whatever else they may be, they are not laws and can be safely ignored" (Wilson 1991, 565).[5]

How, precisely, do initial conditions account for the irregularities in the universe? Due to recent highly detailed maps of the current universe such as the Sloan Digital Sky Survey (SDSS) and the 2-degree Field Galaxy Redshift Survey (2dFGRS) and their juxtaposition with highly detailed observations of the Cosmic Microwave Background (CMB) from projects such as the Cosmic Background Explorer (COBE), the Balloon Observations of Millimetric Extragalactic Radiation and Geophysics (BOOMERANG), and the Wilkinson Microwave Anisotropy Probe (WMAP) it has become increasingly possible to empirically test theories of the quantum origins of the universe. This specialized field, sometimes known as "precision cosmology," sets sharp parameters for plausible theories of cosmology, falsifying many. The current understanding of the initial conditions of the universe, consisting of early inhomogeneities arising from primordial vacuum fluctuations, is beginning to be understood to account for all later inhomogeneities,

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[4] Many philosophy articles that do mention initial conditions do so within a modal or "possible worlds" context, discussing the necessity/contingency of laws (e.g., Schlesinger 1987; Sklar 1991; Beebee 2002; Bird 2002); the direct relevance of these to our discussion of explanation in the actual universe is not clear (although see Frisch 2004 for a possible exception).

[5] Even when initial conditions are recognized as important, precisely how and why seldom seems to be pursued by philosophers. For example, in their discussion of inflationary cosmology Earman and Mosterin state that "[t]hese issues about the nature of scientific explanation and the role of initial/boundary conditions are well worth pursuing, but we will not do so here" (1999, 20).

verifying earlier theories of inflation that predict effects from primordial fluctuations in ways set forth by Albrecht (1996; and contra Earman and Mosterin 1999). These increasingly well-supported theories show how primordial quantum fluctuations were vastly magnified through inflation, and then magnified still further through acoustic oscillations (Whittle 2004). This left a spatial imprint in dark matter leading after recombination to the eventual spatial pattern of condensation of early stars and galaxies. Quite simply, we are beginning to understand the development from the true initial conditions of the universe to the current vast and intricate irregularities of the universe.

Just as quantum cosmologists are beginning to understand the development from initial quantum inhomogeneities to cosmological irregularities, the special sciences have integrated those irregularities into their understanding and explanation in their areas of interest. As noted above, the irregularities imprinted on dark matter, and subsequently on matter, allowed for the condensation of galaxies and early stars. These early conditions were the antecedent conditions for later galaxy and second and third generation (our sun) star formation, with the fate of every star (i.e., becoming helium white dwarfs, carbon/oxygen white dwarfs, supergiants etc.) depending on its initial mass. Each generation contributed to the ever greater proportions of higher elements in the universe through stellar nucleosynthesis, giving the higher elements up to iron, with supernovae giving us the still higher elements. These early processes led to the precise antecedent masses, material composition, velocities, and trajectories of our early solar system and the precise eventual series of collisions and accretion that led to the Earth's distinctive structure. Planetary scientists are beginning to understand how the exact sequence of accretion of the Earth led to critical aspects, such as its large percentage of water (Morbidelli et. al., 2000; Drake and Righter 2002) and how the oblique-angled catastrophic origin of our moon accounts not only for the Earth's unique spin-axis inclinations crucial to our seasons and tides crucial to evolution, but possibly even for the unique plate tectonic activity of the Earth that is responsible for its remarkable diversity compared to other planets (Hoffman 2001a, 2001b). Biologists in turn explain speciation through incorporating the tectonic plate-driven antecedent variation in environments. (Much of this story is the story of ever greater irregularities and hence complexity of interactions. Occasionally, however, there are even still *direct* effects of ancient spacetime trajectories on higher order phenomena, as with the K-T event 65 million years ago and evolution. More speculatively, it is possible that the spacetime trajectory of our solar system still directly affects our weather as the entire solar system passes through nebulous arms of our galaxy, causing or helping to cause ice ages on Earth [Yeghikyan and Fahr 2003, 2004; Gies and Helsel 2005].)

Incredibly, there is beginning to be a unified account in theory and increasingly verified empirically – with many gaps to be sure – between the quantum fluctuations in the early universe to the irregularities of our solar system to the irregularities on our planet, and even to how these irregularities lead to weather systems today (for example, our extremely recent understanding of the El Niño-Southern Oscillation [ENSO] on global weather patterns). This unified understanding is reflected, for example, in the “Cosmic Evolution” project at the Wright Center at Tufts University (“Wright Center”), telling a unified story from primordial quantum physics through galactic, stellar, and planetary formation to biological speciation; a similar effort is found in Morowitz 2002. In effect we have, in theory at least and increasingly supported by empirical evidence, “explained the wind in St. Stephen’s Square.” This has been done entirely within the fundamentalist conception of laws, but through the use of initial and antecedent conditions.

4. Initial Conditions and “Systems.” The previous section discussed how initial and antecedent conditions are able to account for the irregularities in the universe. But what is the relationship between irregularities in the universe and the concept of "system," especially "open" systems (and their necessary corollary, "exogenous factors")? Considering the "decoherence program" in physics helps us see the problem the concept of "system" poses for open system arguments and their relationship to initial conditions.

The decoherence program,[6] like the open-systemist argument, is also based on an emphasis on open systems. Furthermore, it too sees the problematic attachment to closed systems in physics as stemming from a "nomological machines" approach to knowledge in physics: "The idea that the 'openness' of quantum systems might have anything to do with the transition from quantum to classical was ignored for a very long time, probably because in classical physics problems of fundamental importance were always settled in isolated systems" (Zurek 2003, 717). Similarly

> In classical physics, the environment is usually viewed as a kind of disturbance, or noise, that perturbs the system under consideration in such a way as to negatively influence the study of its "objective" properties. Therefore science has established the idealization of isolated systems, with experimental physics aiming at eliminating any outer sources of disturbance as much as possible in order to discover the "true" underlying nature of the system under study. (Schlosshauer 2004, 1273)

The similarity between the emphasis on the failure of closed systems to provide a useful picture of the universe by open-systemists and in the decoherence program is striking.

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[6] The study of quantum-to-classical transitions with an emphasis on their ubiquity in our universe of open systems. Systems can be caused to decohere by outside interference as faint as radiation from the Cosmic Microwave Background (Zurek 1991).

Some (e.g., Auletta 2000, 289; Zeh 2005) view decoherence as a possible solution to essential problems of quantum physics, notably the measurement problem. However, there is a fundamental problem with decoherence as something more than a useful approach to comparing existing interpretations of quantum mechanics and perhaps pointing to new interpretations. Crucially, we believe exactly the same problem exists for open system arguments against fundamentalism, yet remains unacknowledged. This problem concerns the concept of systems: "In particular, one issue which has been often taken for granted is looming big, as a foundation of the whole decoherence program. It is the question of what are the 'systems' which play such a crucial role in all the discussions of the emergent classicality" (Zurek 1998, 1818). Similarly, Schlosshauer writes:

> [T]he assumption of a decomposition of the universe into subsystems—as necessary as it appears to be for the emergence of the measurement problem and for the definition of the decoherence program—is definitely nontrivial. By definition, the universe as a whole is a closed system, and therefore there are no "unobserved degrees of freedom" of an external environment which would allow for the application of the theory of decoherence to determine the space of quasiclassical observables of the universe in its entirety. Also, there exists no general criterion for how the total Hilbert space is to be divided into subsystems, while at the same time much of what is called a property of the system will depend on its correlation with other systems. This problem becomes particularly acute if one would like decoherence not only to motivate explanations for the subjective perception of classicality…but moreover to allow for the definition of quasiclassical "macrofacts." (Schlosshauer 2004, 1274)

Open system anti-fundamentalist arguments face the same problem, viz. What is a (sub)system? Where do they come from? If we cannot answer these questions then both the decoherence program *and* open systems arguments like those of Bhaskar and Cartwright face the fundamental dilemma Zurek and Schlosshauer point out. (We believe the problem raised by Zurek and Schlosshauer strongly applies to Bhaskar/Cartwright type open system arguments. However, the decoherence program itself may surmount the problem. Primordial decoherence is consilient with and probably essential to any future understanding of primordial quantum inhomogeneities and their amplification to subsequent quasiclassical structure in the universe. See Kiefer and Polarski 1998; Kiefer, Polarski, and Starobinsky 1998; Kiefer et al 1998; Barvinsky et al 1999; Lombardo 2005.)

The term "system" is well-known for being difficult to define (see Marchal 1975), indeed there is no universally agreed upon definition. A closely related and equally problematic term is "structure." For example Shapiro (1997) defines structure in terms of systems: structure is "the abstract form of a system, highlighting the interrelationships among the objects, and ignoring any features of them that do not affect how they relate to other objects in the system" (74); he later remarks that "What is structure from one perspective is system from another" (94).[7]

Whatever their precise relation, the concepts of (physical) system and structure share the same fundamental problem: The universe as a whole is a system or structure, yet there is no non-arbitrary way to divide the universe into subsystems or smaller structures. Crucially, our divisions seem merely to reflect our anthropocentric perspective, pragmatic goals, and cognitive needs. We see (or create) groups of

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[7] Open-systemists also use the terms interchangeably, e.g. in reference to economics and its "concepts" (law-like regularities) Cartwright states that: "nothing follows from the concepts themselves without embedding them in a structure, and only special structures [i.e. "nomological machines"] will yield any deductive consequences at all" (2002b, 147).

objects acting in some way and idealize them as a system – a machine, a government, a galaxy, a solar system, a planet, an ecosystem – in order to understand their properties that interest us. But the boundary conditions that define these systems (or structures) are idealized by humans. There may well be steep changes in matter densities, types, or other properties that form apparently natural boundaries and define a system (as in a solar system), but these are never complete; idealized systems are in the end open. A paradigmatic example might be the idealization of our sun and its planets as a solar system but our later understanding that this is more open than we expected, with the Oort Cloud spawning comets reaching the interior of the system from influences as distant as passing stars and interstellar molecular clouds. Because there never seems to be true closure in the universe, the problem with all subsystems becomes one of boundary conditions regressing to the true initial conditions of the universe. This is a problem even in our most abstract theoretical concept of system/structure, much less in our 'messy' universe of open systems. For example, Carter remarks that "mathematicians prove things about smaller structures by placing them in larger ones" (2005, 298). (The problem of boundary conditions within boundary conditions leading back to the beginning of the universe is of course well known, e.g., Causey 1969, 232 and Price 2002, section 3.1. Bhaskar notes this possible objection to his argument [1975, 68-69] but does not develop a defense against it).

As we saw in Section 4, quantum cosmology has begun to explain how primordial inhomogeneities led to the later inhomogeneities of our universe. We propose that it is these inhomogeneities (and their subsequent interactions) that motivate our idealizations of systems and structures. This is evident in the way these concepts are defined in terms of entities that occupy space, that is to say, *spatial irregularities* (i.e. "objects" and "components"). For example, "system" "implies an interconnected complex of functionally related components" (Churchman, Ackoff, and Arnoff 1957, 7) and "[a] system is a set of objects together with relationships between the objects and between their attributes" (Hall and Fagen 1956, 18). Even in the most abstract approach to the concept of system and structure, mathematics, these are defined in spatial terms. A system is "a collection of objects with certain relations" (Carter 2005, 293, summarizing Shapiro 1997) and a structure is "a collection of places with relations and/or functions defined on those places" (Carter 2005, 305, summarizing Resnik 1997). Indeed, if we could somehow imagine a *perfectly* homogenous universe it would seem impossible to imagine how systems/structures might exist. There would be no components or objects to interact with one another. Crucially, it is the development from primordial irregularities of the later irregularities in the universe that gives us "objects" and "components" that can interact and which we idealize as systems or structures. Open system anti-fundamentalist arguments are silent on this issue. The fundamentalist approach (with initial conditions), however, is both theoretically and increasingly empirically successful in accounting for the irregularities that form the basis for human conceptions of system/structure.

5. Why Initial Conditions Are So Often Ignored. If initial conditions are so important, why are they so frequently ignored, as we saw in Section 2? One possibility is that the focus by philosophers on the heroic period of law seeking from the Enlightenment to the twentieth century has served to obscure the importance of initial conditions to the philosophy of science. There are likely at least two more reasons, (i) our anthropocentric view of time and (ii) quantum uncertainty.

An anthropocentric view of time seems to make us loath to the idea that ancient initial conditions control outcomes on cosmological time scales. For example, in a frequently cited passage (e.g., Clarke 1999, 9-10; Waldner 2002, 21) from *The Chances of Explanation*, Humphreys asks us to

> Consider a man who, on a whim, takes an afternoon's motorcycle ride. Descending a hill, a fly strikes him in the eye, causing him to lose control. He skids on a patch of loose gravel, is thrown from the machine, and is killed. This sad event, according to the universal determinist, was millions of years beforehand destined to occur at the exact time and place that it did…This claim, when considered in an open-minded way, is incredible. (Humphreys 1989, 17)

Yet human incredulity is not a firm basis for a philosophy of science. If we are to believe that some "uncaused cause" has intervened between the initial conditions of the universe and later outcomes, it must be shown how, when, and where this has occurred. So far this has not been done.

Just as with Humphrey's rejection of the effect of initial conditions over large time scales, so too with quantum phenomena: If we are to claim quantum uncertainty has made the universe fundamentally probabilistic at the quasiclassical level, we must show how and when. It is natural that a belief in ontological chance would reduce the emphasis placed on initial conditions in the philosophy of science. The hallmark of deterministic systems is extreme sensitivity to initial conditions, while in indeterministic systems their importance is greatly diminished (because of the opportunity for "chance" to change outcomes; this seems especially likely over long time periods, hence Humphrey's view). The open-systemist neglect of initial conditions and its attack on "fundamentalism" is part of a broader anti-deterministic (or pro-probabilistic) consensus that stems in part from the advent of quantum physics. Cartwright introduces *The Dappled World* by declaring that "[f]or all we know, most of what occurs in nature occurs by hap" (1999, 1) while Bhaskar pronounces regularity determinism "a mistake, which has been disastrous for our understanding of science" (1975, 69).

Despite common conceptions, however, it is not at all clear that quantum physics has overturned determinism (Earman 2004). The very difficulties encountered by the probabilistic consensus in providing a coherent model of explanation in our view suggests something fundamentally wrong with the probabilistic assumption (i.e., the failure of *all* attempts to form consistent accounts of macro- and probabilistic causation, with "causation" remaining an inelegant folk science [Norton 2003], while a conserved quantity, non-probabilistic [i.e. deterministic], reductionist [i.e. non ontological-emergentist] view of causality remains, it seems, entirely intuitively *and* theoretically coherent [Burock 2004]). Rather than continuing on what has proven to be a barren intellectual path (at least for reaching a consistent understanding of explanation), perhaps it is time to pay more attention to initial conditions and how, together with laws, they can and are explaining the (weak, non-ontological) emergence of and interactions between the many phenomena in the universe that interest humans. As Halonen and Hintikka state, "finding the right 'initial conditions' is in practice usually the most important part in the process of explanation" (2005, 48). Indeed, for explaining much of what interests philosophers, scientists, and laypersons alike about the universe and our world initial conditions are in a sense significantly *more* important than laws, because while laws constrain, it is initial conditions that account for the initial variation and subsequent rich and beautiful complexity in the universe.

6. Conclusion, and How Quantum Indeterminacy May Still Cause the Perception of Chance in the Universe. Cartwright has written that once we "climb up" to the most fundamental laws of nature, there is no way "within a pure regularity account to climb back down again" (1999, 95, a point she reemphasizes in 2002a, 438, note 15). Yet this is precisely what antecedent conditions, traced ultimately back to true initial conditions, allow us to do. They provide the rough surface, as it were, on which to apply our climbing toolkit of laws, allowing the descent to the concrete situations we want to explain. Furthermore, the irregularities that can be traced to initial conditions account for the anthropocentric perception of systems and their exogenous factors. Open system arguments, however, are tellingly silent on the ontology and origins of "systems" – the very basis of their argument.

Overall, humans seem to have a deep desire to see causal relations between the emergent irregularities ("systems," "structures," "objects," "components") of the universe, and thus we look for non-existent constant conjunctions between these. We agree with open-systemists such as Bhaskar and Cartwright that these do not exist, and that this is a highly significant fact. But the empirically supported interpretation of this fact is that the macro relations that we do see are spatiotemporal *trends*, trends that ultimately stem from irregular micro initial conditions in a universe with universal laws.

Interestingly, the primordial onset of ubiquitous decoherence suggests that the significance of quantum indeterminacy to explanation in our quasiclassical universe may need to be reconsidered. Quantum indeterminacy may yet be understood to define much of what our classical universe is like. But not through undermining universal laws and introducing ontological chance directly into the post-inflationary universe, but rather through primordial vacuum fluctuations providing the universe with irregular initial conditions, and thus transmitting the contingency of quantum phenomena throughout the universe by way of the spacetime trajectories of matter.

Addendum. The open system rejection of laws of nature brings to mind a problem recently pointed out with an idealized Newtonian universe. McAllister (1999 and 2004) shows that a Newtonian universe is inconsistent. The traditional conception of a Newtonian universe is that it is governed by laws and initial conditions, and consistent with the D-N model of explanation (McAllister 1999, 327-328). If we want to explain, say, the motion of a body in a solar system within a Newtonian universe we would consider the laws of motion in that universe, along with the initial velocities, trajectories and masses of the bodies in the solar system. However, the inconsistency that McAllister points out is that there is no way to introduce initial conditions into a Newtonian universe. These would be, in effect, a set of impermissible exogenous factors in what is by definition an isolated system. Thus one must posit laws that explain the solar system in question; this regresses infinitely, so there can never be any initial conditions in a Newtonian universe. Ergo, it must have no initial conditions, and be defined only by laws.

However, as McAllister notes, he is only pointing out an inconsistency in our concept of an idealized Newtonian universe (2004, 203); this critique does not apply to our universe because it seems to have a beginning, the Big Bang. In our universe there are initial conditions as well as regularities (that may be universal laws of nature), thus our real world does not fall into the paradox he points out for a Newtonian universe. Cartwright's claim that "[t]he only way a condition could restrict the range of an association in a principled or nomological way would be via a more complex law" (Cartwright 1999, 138) is like McAllister's observation of the inconsistency of a Newtonian universe that can only have laws. But just as we can immediately see that this inconsistency most likely does not apply to our universe because it has initial conditions, so too we can see how easily open system objections are resolved by initial conditions. The crucial question is not whether the open-systems view is more compelling than a scientific attempt to account for the complexity of our universe through laws "all the way down," but whether it is more compelling than a scientific attempt to explain the complexities of our universe with laws *and* initial conditions.[8]

[8] This of course begs the question of whether we can explain the beginning of the universe, as in chaotic inflation, multiverse and anthropic principle scenarios (Tegmark 2004 provides a useful classification of the possibilities). This is beyond the scope of our discussion. However, it is possible that laws, constants, and initial conditions of the universe may simply have to be accepted as "brute facts" (see Callender 2004).

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