DUALITY THEORY III: INTRODUCING THE USE OF COUNTERPARITY DIAGRAMS TO DETECT AND DEFINE EMERGENT HIERARCHICAL LEVELS

Len Troncale, Dept. of Biology, and
Institute for Advanced Systems Studies
California State Polytechnic University
Pomona, California, USA, 91768

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INTRODUCTION TO THE PROBLEM

Two study groups of the International Society for the Systems Sciences (ISSS) have independently explored the structures and processes of duality theory and hierarchy theory and their relations to systems dynamics over the last five years. During these meetings it became clear that researchers in each group were vitally interested in the results of the other group. The phenomena of hierarchy and duality seemed to be tightly interconnected. This year the two groups meet jointly to explore and attempt to specify this interrelation and to provide a model for future synthesis-oriented "joint" meetings of established ISSS Special Integration Groups. It is hoped that a more complete and useful general theory of systems will gradually emerge from this mechanism of joint meetings for synthesis between S.I.G.'s highly focused on individual putative isomorphies. Each attempted joint meeting will enable inclusion of more detail and yet simultaneously more depth.

A consistent problem encountered in research on hierarchical form is the problem of "relativism." Many different workers perceive a number of conflicting and inconsistent hierarchies of levels when examining the same set of real objects in nature. Although, this problem might be expected when examining the social hierarchy, it appears with just as much ferocity in the natural sciences, particularly in the range of scales from molecular biology to ecology (as clearly illustrated by Salthe, 1985). The counterparity diagramming method introduced in this paper may provide one of hopefully several techniques to approach resolution of this problem.

Another problem concerns the source of mutuality of interest between the results of duality theory and hierarchy theory. Why have researchers in each specialty found it <u>necessary</u> to refer to the results of the other specialty in order to make sense of their own. This implies there is an intertwining of mechanism between the two which is not yet fully specified. Counterparity diagramming describes a natural mechanism by which hierarchies result from dualities, thus indicating why the two must be discussed together.

Finally, the third problem concerns the identification of a natural mechanism for emergence of new levels. Some choose to term this systems evolution, although I have argued against this because of distinctions that clearly exist between evolution and emergence (Troncale, 1981). Counterparity diagrams might possibly help in delineating the elusive mechanism behind "systems emergence."

Research into solving these problems must satisfy the following criteria for systems investigations at the Institute for Advanced Systems Studies: (i) it should have an empirical base; (ii) it should utilize tests for components of the theory by detailed examination of real, natural systems; and (iii) it must contribute to elucidation of detailed comparisons across disciplines.

INTRODUCING COUNTERPARITY DIAGRAMS

We here introduce a method for diagramming selected empirical measurements for objects in the natural world. The method will illustrate that these objects themselves, as well as some of their most important scalar characteristics, result from the interaction between dual opposite forces. In past papers we suggested that these opposing forces should be called "counterparities" to distinguish them from the popular, but ill-defined term "dualities". We also surveyed a series of many levels of biological hierarchies in past papers (e.g. Troncale, 1985) to enumerate and analyze 55 specific examples of counterparities possibly involved in the generation of those bio-hierarchies. From this analysis of numerous putative dualities in biosystems, we derived the concept of "diagramming" dualities to test whether or not they satisfied the performance criteria for counterparities. For example, in biohierarchies it is clear that only a few of the 55 dualities originally found actually contribute directly to the formation of objects on a level; the others are "noise" to perception of the centrally important counterparities.

Counterparity diagrams (hereafter CP diagrams) show how the forces active on any particular level give rise to the diversity of objects found at that level. The X axis of a counterparity diagram is occupied by increments of magnitude for one of the two opposing forces that disciplinary specialists recognize causes the objects to form. The Y axis is occupied by various increments of the opposite force. The "space" that depicts all of the possible combinations of X versus Y encompasses all possible objects, some with much X and little Y, some vice versa, and some fewer with exact balances of X and Y.

That nature, once the forces themselves are established for the "korperplan" for that level, produces however fleetingly, all of these possible combinations is given. The surprizing correlation across such counterparity diagrams is that, whatever the level, only a small band of all possible objects actually occur in nature. Identification of the band of objects requires selection of the right set of dual opposite forces from among the larger group of all possible forces active on any one level. But given this identification, bands from different levels seem to share certain quantitative similarities which we will report in a subsequent paper.

The various combinations of X and Y forces possible in the space of this Cartesian coordinate system lead to relative neutrality (satisfied complementarity) and thus to stablity of the objects so formed. It is this relative stability that allows humankind to recognize them as objects. On CP diagrams they last long enough to discover and label. But these existing objects are only "relatively" stable because many do not possess exact balance of both X and Y, and the leftover (unsatisfied counterparity) actually become the "forces" for generation of the next level. The many diverse objects (with a Poisson distribution of unsatisfied counterparity) themselves interact and bind together using these leftover forces and so generate still another level or CP diagram with a new Korperplan.

The diagrams also describe "exotic" and short-lived states that can be created, but are unstable. It is important to recognize these "unseen" states and characterize them for a complete systems understanding of any level. Previous work ignored such "unseen" objects, and so could not recognize the true perimeters of the "potential space" and crucial limits for that space as depicted in CP diagrams. The overview of all possible objects yields a more complete, and useful view of the "potential space" of an entire hierarchical "level" of objects, and is thus more useful in investigating emergence theory and hierarchies.

Therefore, these diagrams serve two purposes. They demonstrate the formation of objects in terms of conventional mechanisms to the satisfaction (and easy recognition) of diverse specialists in the disciplines. Simultaneously, they show the limits and bounds for "emergence" of the level and objects on the level to cross-disciplinary investigators. They link conventional and systems approaches because of their significant trans-disciplinary aspects. Their comparison reveals a detailed and empirically-driven mechanism with systems-level features of its own. This "systems-based" mechanism becomes then a candidate isomorphy like hierarchy theory, emergence theory, and self-organization (which isomorphies it helps explain).

CASE STUDY I: A COUNTERPARITY DIAGRAM FROM CHEMISTRY

The first set of diagrams presented in the talk will be of rather well-known depiction of the process of nucleosynthesis in atomic particle physics, but which also has implications for the chemistry of elements. On the Y axis we place the proton number for a number of different elements. On the X axis we place the neutron number. In actual terms, the balance between the positive forces of the protons in the nucleus are balanced by the negative forces of the electrons in the shell of the atoms. But here we are dealing with the stability of the nucleus of each element, so the opposite force of electronegativity is replaced by the neutral mass of the neutron.

The stable nuclei are shown as solid points, the unstable, or radioactive nuclei are shown as open circles. The letters are the usual symbols for the elements with N = 2 to 34 and Z = 2 to 32. Note that all isotopes and elements known to man are found in a band that roughly balances, or nearly balances the two opposing influences (which are also reflected in the electron shell, and so in the elements chemistry). It is known that man can fleetingly create in the laboratory a number of nucleosynthetic complexes not in the region of this tight band, and also not found in nature, but they do not possess half-lives sufficiently long to study. Studies of hundreds of such complexes prove that the band is a real phenomenon given our normal space-time environment and man-made complexes that exceed the bounds cannot survive.

CASE STUDY II: A COUNTERPARITY DIAGRAM FROM ASTROPHYSICS

Another putative counterparity diagram appears in classic studies in astronomy, the well-known Hertzprung-Russell diagrams. In these, the masses of stars are graphed against their luminosity. A third set of redrawn conventional discipline charts will be presented at the talk to show a counterparity diagram for stars and astrophysical dynamical systems.

Although, strictly speaking, mass and luminosity are not opposing forces, this suggested CP diagram illustrates how analysis of data generated by the disciplines with slightly new emphases can contribute to systems theory. The mass of a star is caused by gravitational attraction and is quantitatively related to such. The luminosity is related quantitatively both to the mass and the intensity of thermonuclear fissions and fusions. The fission and fusions are the explosive forces active in star formation and dynamics, that, if not matched by the implosive (or gravitational) forces, would render the star quickly unstable. Thus, mass and luminosity are indirect but quantitatively related measures of the opposing implosive and explosive forces that account for the nature of stars.

The most stable stars, and the longest lived are found in one band across the Hertzprung-Russell diagram. Other stars live comparatively much shorter lifetimes, as in the case of nuclear structures shown above, and the leap to the other domains of the HR diagram are very rapid, usually across "gap" regions. If altered slightly (or more properly directly redrawn from the specific data on gravitational versus nuclear explosive forces), the resulting CP diagram has the interesting feature of describing a band with a negative slope versus the other positive slopes thus far encountered.

CASE STUDY III: A COUNTERPARITY DIAGRAM FROM ECOLOGY

Ecologists have been constructing specific food webs for decades and conducted empirical investigations to verify their structure and interconnection. Briand and Cohen (1984) examined no less than 62 of these food webs which had survived peer review in their respective disciplines, and compared them for invariant structure. They were surprized to find a cross-example regularity in two ways. The proportions of top, intermediate and basal species are, on average, independent of the total number of species involved in each web. Thus, there is evidence for "a direct proportionality between the numbers of prey and predators."

The second set of Figures presented at the lecture will be redrawings of their results across 62 community food webs. Prey and predators may be considered for the purposes of our CP diagram as "force vectors." It is clear that they are variations on the same theme, but are exactly opposite in direction. Their interaction upon each other is literally what makes up the new "level" of "community" in the biological hierarchy so formed, just like the interaction between neutron and proton make up the new level of chemical element from sub-atomic particle. Again, we find the "band" of stable associations that is rather narrow considering all possible combinations that are described by the "potential space."

It is interesting to note that the "band" is found to be more constrained in fluctuating than in constant environments in this study. This feature of the band was not studied in the other two case studies, but cross-level comparisons like these lead to suggestions for more study in other cases contributing to detail across all levels.

SELF-SIMILAR VERSUS UNIQUE FEATURES OF COUNTERPARITY DIAGRAMS WHEN COMPARED ACROSS DISCIPLINES AND EMERGENT HIERARCHICAL LEVELS

Examination of these particular examples of counterparity diagrams indicates that they have several features in common. These common features should be of interest to systems science since they are clearly trans-disciplinary aspects of nature. That they are common for three selected case studies does not prove that they will survive tests for commonality when other cases are examined. But for the sake of argument and synthesis - the hallmark of systems science - we would propose the following general conclusions to be true of many natural systems when they are non-anthropomorphically defined. Though stated as conclusions below, they are most properly depicted as intriguing conjectures or hypotheses to be tested further.

(1) Each object defined by a science appears to result from a dynamic balance between two major forces rendering it stable. Other forces certainly exist on these levels, but

only two major forces dominate the formation and stabilization of systems typical for that level. The balancing of the two forces results from a tendancy to neutralize the vectors of the two forces in each object. Or state more precisely, and exactly oppositely, the tendancy to neutralize the two forces results in the self-generation of a variety of forms, only the stable versions of which are normally observable by humankind.

(2) The juxtaposition of the two forces defines all possible combinations and visualizes a total "potential field" which is defined in the act of "diagramming" all the observed objects within the putative level.

(3) The balance achieved for the objects within an emergent level as defined by counterparity diagrams is not identical; each level has its own complementary ratio of the two forces which results in a diversity of objects for each scalar level built, however, on the same body plan (korperplan) typical of all objects on that level.

(4) Only a small number of all of the possible combinations of the dual forces made possible by the opposing forces actually appear in nature.

(5) These "stable" combinations are restricted to a narrow band of possibilities no matter what the scalar level, although the slope of the band differs for each level.

(6) The ratio of stable to unstable combinations is nearly constant across many scalar levels, especially across cohorts of levels.

(7) These "stable" combinations are restricted to a narrow band of possibilities no matter what the scalar level. The slope of this band of realized/actual stable systems as opposed to possible systems is different for each scalar level.

(8) There is a distinct upper limit beyond which even the band of otherwise "stable" combinations of the dual forces disintegrates. No objects appear in nature beyond this limit even though possible combinations exist according to the counterparity diagram. The parameters that define this limit are the same across all verified counterparity diagrams. To simplify discussion of this proposed "limit" we have named it the Wilson-Troncale limit. It is our conjecture that the Wilson-Troncale limit will be a constant or invariant limit in natural science, and it will prove to be critical to understanding what emergence is and how it works.

(9) The CP diagrams studied so far suggest that it would be beneficial to use the tools of chaos recently introduced to study the parameters of these systems or levels of organization. They certainly all comprise complex dynamical

systems. But in addition, the "band" at each level appears to us to be a dampened attractor in a phase space created by the counterparities. This together with the linkage between hierarchical levels and the obvious nature of continuity to discontinuity to continuity to discontinuity aspect of chaos models and the order-disorder thus introduced suggest that the two phenomena might be used to explain each other.

OTHER POSSIBLE USES OF COUNTERPARITY DIAGRAMS

It has not escaped our notice that the putative CP diagrams suggested above are associated with rich literatures that have a great deal of associated empirical measurements available. This immensely enhances our potential to test, eliminate and/or extend the observations and conjectures presented above, as well as explore in meaningful and falsifiable ways the uses of CP diagrams in systems science.

Of the many possible uses of CP diagrams, we list the following: (1) One of the persistent problems in hierarchy theory is the plethora of levels that may be compared to find what is common across natural hierarchies. In Troncale, 19xx, we presented initial empirical evidence that there are at least two, if not more, distinctly different "kinds" of hierarchies which frustrate attempts to find consistent comparisons because this fundamental distinction between levels arising from "subspecialization" processes are confused with those arising from "emergence" processes. CP diagrams appear to be useful in distinguishing between "emergent" and "specialization" based hierarchical levels. (2) These diagrams can also be used to filter out the more fundamental from less fundamental dualities active on different levels, thus helping duality research directly by filtering out noise. It appears that many of the dualities that can be observed in the natural sciences do not influence the origins of natural objects at all. (3) CP diagrams could be used to improve our recognition and definition of what are truly emergent qualities on any given level, even providing an empirically-based demonstration of new forces and qualities for each level. Finally, (4) we intend to attempt construction of CP diagrams on the social science or organizational levels to test whether or not natural and social systems have this feature in common. This will contribute to the debate on whether it is beneficial or not to bridge the gap between natural systems and social systems on our way to attempted formulation of a unified systems science body of knowledge and practice.

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