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Map of the Physical Sciences

Kevin W. Boyack
Sandia National Laboratories*
P. O. Box 5800, MS-0188
Albuquerque, NM 87185
kboyack@sandia.gov

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Various efforts to map the structure of science have been undertaken over the years. Using a new tool, VxInsight™, we have mapped and displayed 3000 journals in the physical sciences. This map is navigable and interactively reveals the structure of science at many different levels.

Science mapping studies are typically focused at either the macro- or micro-level. At a macro-level such studies [1-3] seek to determine the basic structural units of science and their interrelationships. The majority of studies are performed at the discipline or specialty level [4-7], and seek to inform science policy and technical decision makers. Studies at both levels probe the dynamic nature of science, and the implications of the changes.

A variety of databases and methods have been used for these studies. Primary among databases are the citation indices (SCI and SSCI) from the Institute for Scientific Information, which have gained widespread acceptance for bibliometric studies. Maps are most often based on computed similarities between journal articles [1] (co-citation), keywords or topics [2,5,6] (co-occurrence or co-classification), or journals [3,4] (journal-journal citation counts). Once the similarity matrix is defined, algorithms are used to cluster the data.

DISCLAIMER

The standard mapping output is a circle plot in which each cluster is represented by an appropriately sized circle. Links between circles provide relationship information. However, most outputs are paper-based and only resolve structure at a few discrete levels.

We have developed a method and tool to map and interactively navigate the structure of science. An early version of this mapping and visualization tool, VxInsight™, was first profiled by *Nature* [8] in 1996. Features in the current version include drill down, peak labeling, time-stepping and database query [9].

Our map of the physical sciences (Fig. 1a) was created from the roughly 3000 journals and 4.7 million articles in the physical sciences subset of the SCI from 1981-1996. The similarity between journals was defined as (A cites B) + (B cites A) where A and B are any two journals. Subsequent clustering of journals was done with a force-directed placement algorithm [9] which pits the attractive forces of similarity values against a repulsive density grid. This algorithm places similar objects close together, and dissimilar objects further apart. The number and size of clusters is thus emergent from the data rather than pre-specified.

In our map of the physical sciences, physics is a large peak that occupies a central position. Engineering disciplines, mathematics, computing, and materials science all surround physics with strong links to physics journals. Various chemistry disciplines occupy the ridge on the right edge of the map and have strong connections back to physics as well as to materials and geology. At the macro-level this map has much in common with the physical sciences portion of the map in reference 3.

A close-up view of a cluster in the center of the astrophysics peak (Fig. 1b) shows strong relationships (blue lines) between major journals in that field. It is interesting that *Nature* appears in this cluster, although it is a multidisciplinary journal. When life sciences are not included in

the map, *Nature's* strongest links are to well known astrophysics journals. When life sciences are added to the journal set, we expect this map to change due to the impact of new strong linkages.

Although the present study has focused on physical science journals, VxInsight™ has been successfully used for studies at the discipline level based on articles. We have also successfully mapped other databases, such as those containing patent, genome, and transactions data.

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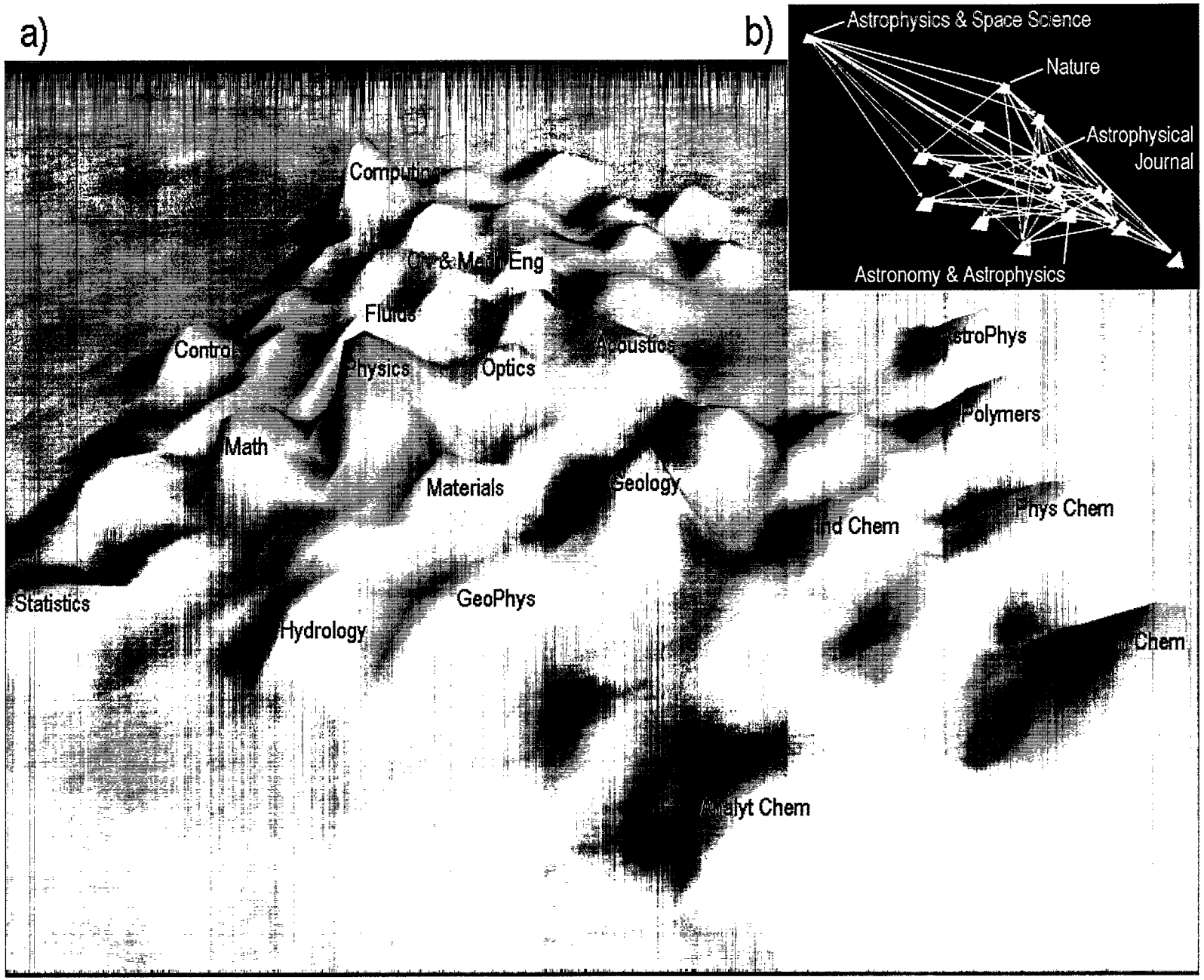
Figure 1a) Landscape of the physical sciences displayed in VxInsight™. The height of a peak represents the number of journals under the peak. Journal positions were calculated based on journal-journal citation counts. **1b)** Detail on the Astrophysics cluster from 1a. Each pyramid represents one journal. Strong links between individual journals in the cluster are shown as blue lines.


a)
b)
Astrophysics & Space Science
Nature
Astrophysical Journal
Astronomy & Astrophysics
Computing
Fluids
Control
Physics
Optics
Acoustics
Math
Materials
Geology
Polymers
Phys Chem
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