《圣经》 第二章 · 开篇

There are many reasons why conical refraction is worth revisiting:

(i) It was an early (perhaps the first) example of a qualitatively new phenomenon predicted by mathematical reasoning. By the early 1800s, it was widely appreciated that mathematics is essential to understanding the natural world. However, the phenomena to which mathematics had been applied were already familiar (e.g., tides, eclipses, and planetary orbits). Prediction of qualitatively new effects by mathematics may be commonplace today, but in the 1830s it was startling.

(ii) With its intimate interplay of position and direction, conical refraction was the first non-trivial application of phase space, and of what we now call dynamics governed by a Hamiltonian.

(iii) Its observation provided powerful evidence confirming that light is a transverse wave.

(iv) Recently, it has become popular to study light through its singularities (Berry [2001], Nye [1999], Soskin and Vasnetsov [2001]). In retrospect, we see conical refraction as one of the first phenomena in singular polarization optics; another is the pattern of polarization in the blue sky (Berry, Dennis and Lee [2004]).

(v) It was the first physical example of a conical intersection (diabolical point) (Berry [1983], Uhlenbeck [1976], Berry and Wilkinson [1984]) involving a degeneracy. Nowadays, conical intersections are popular in theoretical chemistry, as spectral features indicating the breakdown of the Born–Oppenheimer separation between fast electronic and slow nuclear freedoms (Cederbaum, Friedman, Ryaboy and Moiseyev [2003], Herzberg and Longuet-Higgins [1963], Mead and Truhlar [1979]). By analogy, conical refraction can be reinterpreted as an exactly solvable model for quantum physics in the presence of a degeneracy.

(vi) The effect displays a subtle interplay of ray and wave physics. Although its original prediction was geometrical (Sections 3 and 4), there are several levels of geometrical optics (Sections 5 and 7), of which all except the first require concepts from wave physics, and waves are essential to a detailed understanding (Section 6). That is why we use the term conical diffraction, and why the effect has taken so long to understand.

(vii) Analysis of the theory (Berry [2004b]) led to identification of an unexpected universal phenomenon in mathematical asymptotics: when exponential contributions to a function compete, the smaller exponential can dominate (Berry [2004a]).

(viii) There are extensions (Section 8) of the case studied by Hamilton, and their theoretical understanding still presents challenges. Effects of chirality (optical activity) have only recently been fully understood (Belsky and Stepanov [2002], Berry and Jeffrey [2006a]), and further extensions incorporate absorption (Berry and Jeffrey [2006b], Jeffrey [2007]) and nonlinearity (Indik and Newell [2006]).

(ix) Conical diffraction is a continuing stimulus for experiments. Although the fine details of Hamilton's original phenomenon have now been observed (Berry, Jeffrey and Lunney [2006]), predictions of new structures that appear in the presence of chirality, absorption and nonlinearity remain untested.

(x) The story of conical diffraction, unfolding over 175 years, provides an edifying contrast to the current emphasis on short-term science.

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➢ 锥折射 值得研究 的 10 点理由（Berry）：

1. 首次：先纯数学预测，后获实验验证。
2. 首次：相空间、倒空间的应用。
3. 实锤：光是横波。
4. 开启：奇点光学的大门。
5. 等价：量子物理中存在简并的完全可解模型。
6. 纯粹：只能用波动光学解释，几何光学一败涂地。
7. 启发：数学渐近性中存在一种意料之外的普遍现象。
8. 实验：锥衍射 的 更多实验细节，尚未被揭露。
9. 拓展：手性、吸收、非线性，仍是未解之迷。
10. 科学：200 年来展开的锥形衍射研究，与当前对短期科学的强调，形成鲜明对比。

“没有肤浅的学问，只有肤浅的人”

—— Berry

➢ 锥折射 值得研究 的 6 点理由（Xie）：

1. 真实：几乎任何人都可以做这个实验，但几乎没有人能完全理解它。
2. 魔幻：一支激光笔，一块小晶体，一个线性现象，一辈子都无法解释。
3. 检验：对双轴晶体模型 + 各向异性线性衍射波动理论，执行最严格的检验。
4. 拓展：任意光场、不傍光轴，仍是未解之迷。
5. 基础：晶体光学、线性光学、非线性光学，一切波动理论、上层建筑的基础。
6. 智力：持续 200 年的头脑风暴、探索之路，还将前仆后继、薪火相传。