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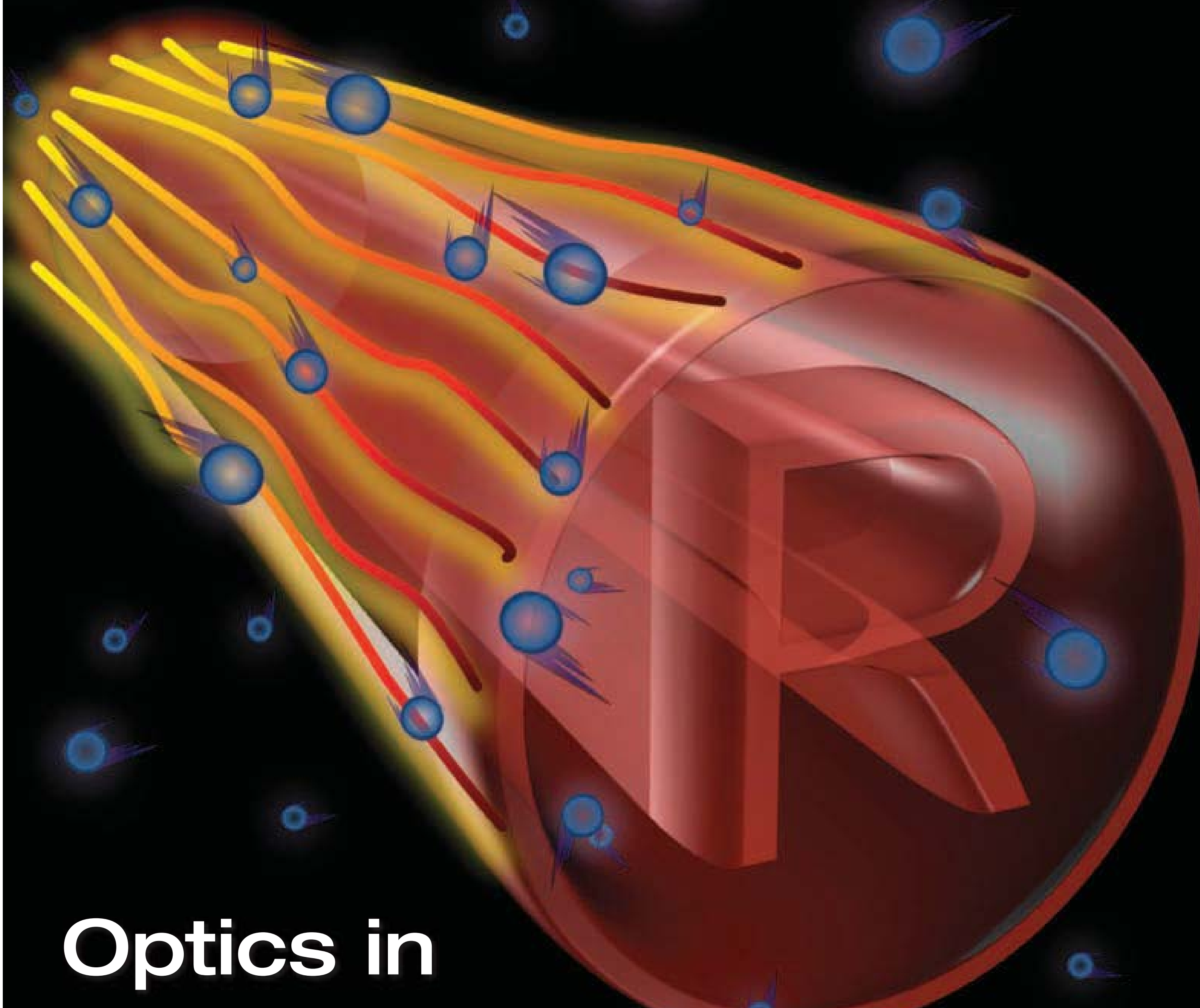

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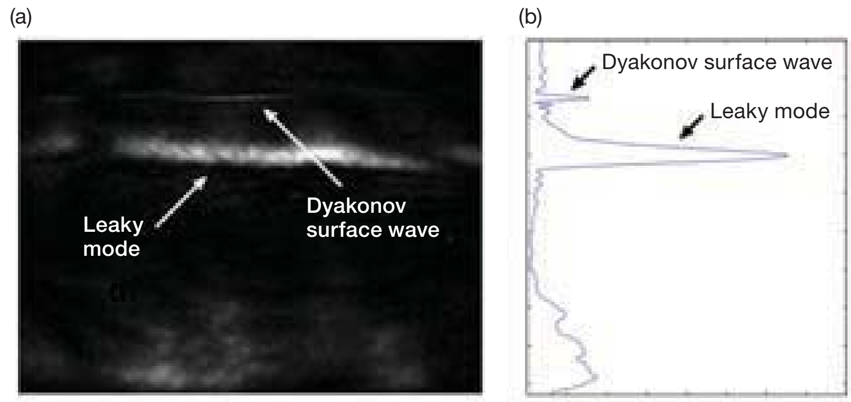
Dyakonov Surface Waves

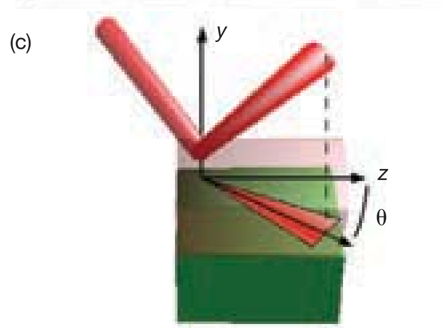
Lluis Torner, David Artigas and Osamu Takayama

Surface waves are a special type of wave that is confined at a single boundary between two different media. They are a topic of continuously renewed interest and intense investigation due to their unique properties and their prospects for important applications. By their very nature, surface waves are unique tools for exploring the properties of material interfaces. This includes not only intrinsic properties but also extrinsic effects, thus making surface waves ideal for sensing physical, chemical and biological agents. Potential applications range from subwavelength light microscopy and nanooptical tweezing, to early diagnosis and minimally-invasive therapy of diseases. However, guided surface waves are rare, as they can be supported by only a few types of materials and geometries.

M.I. Dyakonov predicted a unique class of surface wave two decades ago.[1] Such surface waves exist under very special conditions at the interface of anisotropic crystals—either biaxial or positive uniaxial. Under suitable material and geometrical conditions, hybrid surface waves containing both ordinary and extraordinary field components can propagate within a narrow angular band $\Delta\theta$ relative to the crystalline optical axis. The existence conditions are not easy to meet in practice. Thus, Dyakonov surface waves had never been observed.

The 20-year quest ended this year when we observed Dyakonov surface waves in an Otto-Kretchmann setting set for an isotropic-anisotropic crystal interface.[2] We used a specially designed configuration based on a potassium titanyl phosphate biaxial crystal and a suitable index-matching liquid to meet the conditions required for the existence of the surface waves.[3,4] We confirmed surface wave excitation by imaging the scattered mode spectrum out of the Otto-Kretchmann prism on a CCD camera and obtained the signature of surface wave excitation by using a powerful polarization conversion reflectance technique.





Signature of Dyakonov surface wave excitation. (a) Magnified view of the modal spectrum obtained by a CCD camera. (b) Integrated intensity along the vertical axis. Large peak stands for a leaky mode. The Dyakonov surface waves appear as the weak secondary peak. (c) Narrow angular band where Dyakonov surface waves propagate relative to crystallographic axis *z*.

Technical challenges that we had to overcome included light propagation inside the crystalline angular band, where surface waves were allowed to exist under ideal conditions, and elucidation of the extremely narrow peak corresponding to guided Dyakonov surface waves among the set of broader peaks corresponding to leaky modes supported by the actual Otto-Kretchmann multilayer material structure.

The significance and potential of Dyakonov surface waves relies on their most fascinating property: In contrast to, for example, plasmon-polaritons, they exist at the surface of fully transparent materials; therefore, they are lossless. Their observation opens the door for the exploration of lossless surface wave propagation in a variety of suitable settings, including nanoscale geometries and metamaterial structures with form-anisotropy.[5] ◭

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