amorphous. Between about 850° and 1,000° C, however, a very small amount of this silica reacts with forsterite to form a pyroxene-like structure. Because this phase produces only two very faint powder lines at approximately $d = 3{\cdot}2$ Å and $d = 2{\cdot}9$ Å, it is difficult to characterize the structure with any certainty. We would be very reluctant to identify it with a recognized form of enstatite as suggested by Haggerty and Baker[1]. At 1,100° C the poorly oriented pyroxene-type phase develops much more rapidly, and in an olivine containing approximately 50 per cent of forsterite the original olivine completely disappears. Even at this and higher temperatures, the nature of the structure is uncertain, but it probably resembles proto-enstatite rather than any other enstatite polymorph. Unlike Haggerty and Baker, we find no evidence that the pyroxene is metastable; rather, it is the silica which is metastable in the presence of forsterite.

At temperatures of about 900°–1,000° C, the disorganized silica acquires enough structural regularity to allow the recognition of quartz, tridymite and cristobalite-like forms from their diffraction patterns. Some evidence of embryonic forms of cristobalite is provided by infrared absorption spectroscopy and by a very faint diffuse band of reflexion which occurs on powder photographs at about 4 Å. The orientation of the high cristobalite is

$$(100)_{ol} \| (111)_{cr}\ b_{ol} \| \pm [110]_{cr}$$

which again develops from the structural control of the original oxygen arrangement. Similar control occurs for tridymite, but the quartz is unoriented. In forsteritic olivines, however, this crystalline silica disappears with prolonged heating when it reacts with the forsterite to form more pyroxene.

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PHYSICS

36 GHz Travelling Wave Maser

Amplification of 6 dB has been obtained in a travelling wave maser at 36 GHz using Cr^{+3} doped rutile (TiO_2) as the active material. The slow wave structure is a fully filled wave guide with the crystal orientation designed for push–pull pumping and double ion site operation. A superconducting magnet operating in the persistent mode provides the direct current magnetic field.

All four Zeeman energy levels of Cr^{+3} are used. In the push–pull pumping scheme the pump frequency is applied to the 1–3 transition and the 2–4 transition which are arranged to have the same energy. This overpopulates level 3 and depopulates level 2, producing the population inversion necessary for maser action. The incoming signal, corresponding to the 3–2 transition, gains energy coherently by stimulated emission from level 3 to level 2 (see Fig. 1).

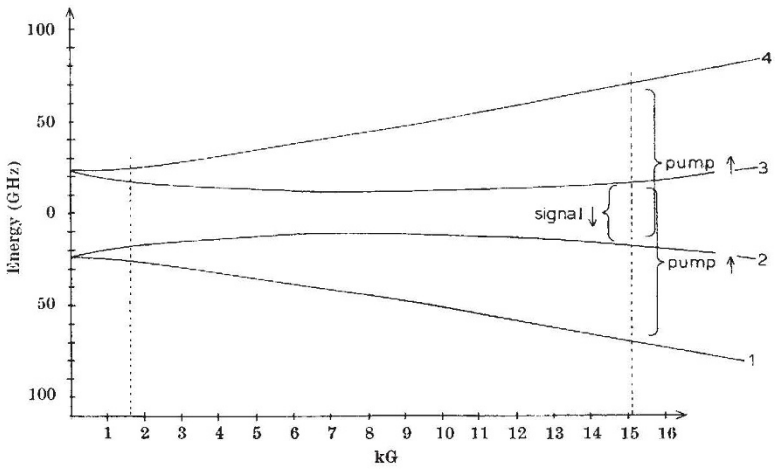

Fig. 1. Push–pull energy levels in rutile.

There are two possible operating points for a 36 GHz signal: a magnetic field of 1·7 kgauss with a pump frequency of 44 GHz or a 15·1 kgauss field with a 90 GHz pump. The latter combination is used because the higher pump frequency (larger inversion ratio) produces a higher maser gain per unit length.

A net gain of approximately 5 dB per cm of slow wave structure with a bandwidth of 80 MHz is observed. The net gain in the reverse direction, with no additional isolation, is zero, the amplification just equalling the paramagnetic absorption.

The maser as constructed for testing purposes consisted of a 0·5 in. section of wave guide, cross-section 0·012 × 0·045 in., filled with three TiO_2 crystals, each 0·012 × 0·015 × 0·500 in. lying side by side. Two of the crystals were doped with Cr^{+3} and the third was pure rutile. Matching to the open RG(96)/U guide was obtained through a tapered matching section containing a tapered rutile crystal. The 90 GHz pump energy was fed into the signal wave guide through a directional coupler.

An operational maser amplifier under construction, designed for at least 20 dB of gain, will have 5 cm of rutile filled wave guide which must be folded twice to fit within the superconducting magnet and to preserve the proper angular relationship between the direct current magnetic field, the radio frequency field and the crystal axes.

The maser amplifier is to be used as a radio frequency preamplifier in radio astronomy.

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Relationships between the Masses of Subatomic Particles

Lewis[1] has asserted that the so-called elementary particles are not elementary but are composed of tamaids and pions. Each elementary particle of mass greater than that of the pion consists of a π-meson as nucleus and tamaids either as a static conglomerate or rotating in various orbits around it. He has calculated the masses of the various neutral and charged particles on the basis of the equations

$$m_{Neutral} = 25{\cdot}95\,n + 134{\cdot}97 \quad (1)$$

$$m_{Charged} = 25{\cdot}76\,n + 139{\cdot}577 \quad (2)$$