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Beam expander telescopes for the Michelson beam splitters in third generation Gravitational Wave Observatories.

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The Einstein Telescope will have Michelson interferometers with Fabry-Perot cavities in the two arms. They will need the widest possible stored beams to reduce thermal noise, using mirror test masses with diameter at the limit of technical feasibility. Recombining those wide beams into the beam splitter would be challenging in any case. Unlike other detectors, the Einstein Telescope will have a 60o angle between the arms. Because of its larger incidence angle, at any given beam size, it would require beam splitters almost double in size and much heavier than the 90o case. It is proposed here to install beam expander telescopes with angled mirrors inside the Michelson, located between the Fabry-Perot cavities and the beam splitter. In addition to reducing the beam sizes to manageable sizes, the proposed solution allows to bring the recombination angle to 90o. As a result, beam splitters more than 100 times lighter can be used. The proposed geometry also offers a natural way to separate the beam splitters of different detectors into individual, smaller and more stable caverns, to provide needed beam diagnostic points and convenient degrees of freedom for beam alignment into both the Fabry Perot cavities and the beam splitter, as well as to provide a method for maintaining optimal mode matching of the two arms onto the beam splitter without thermal compensation plates. This easily offsets the added complexity of controlling the telescope mirrors

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