Fischbach *et al.* Respond: Thodberg[1] and also Hayashi and Shirafuji[2] raise a valid question about the signs in Eq. (4) and the subsequent equations in our paper.[3] We have defined $g=|\mathbf{g}|=G_0M_\oplus/R_\oplus^2$, so that Eq. (4) is correct as it stands for the assumed repulsive force. On the other hand, these authors correctly point out that the Eötvös-Pekár-Fekete (EPF) results, taken at face value, imply that the force actually is attractive, contrary to what we have assumed.

We show elsewhere[4] that one cannot in fact deduce from the EPF data whether the force is attractive or repulsive. The reason for this is that in the presence of an intermediate-range force, local *horizontal* mass inhomogeneities (e.g., buildings or mountains) can be the dominant source in the Eötvös experiment.[4,5] Their effects can be more important than those arising from the Earth as a whole, even though the Earth is the main source of the gravitational force. For this reason one cannot infer either the magnitude or the sign of the EPF anomaly in the absence of a more detailed knowledge of the local matter distribution at the time of the experiment than we presently have available.

To see why this is the case, let us consider the effects of a building and its basement on the Eötvös balance. We approximate the former by a sphere of mass M and radius R, and the latter by a sphere of missing mass M' and radius R'. The centers of each sphere are located at angles ϕ and ϕ' relative to the horizontal, and the experiment is performed at a latitude θ. Finally, we locate these spheres to the north of the apparatus (itself oriented east to west), since we know from the EPF description of the location of their experiment that they were in a room facing south. Then the component of the net torque τ_{net} about the fiber axis $\hat{\mathbf{x}}_3'$ is given by[4]

$$\hat{\mathbf{x}}_3'\cdot\tau_{\text{net}}=m_1l_1\left(\frac{B_1}{\mu_1}-\frac{B_2}{\mu_2}\right)\left(\frac{a\sin\theta}{g}y+y'_{\text{building}}\cos(\phi+\beta)-y'_{\text{hole}}\cos(\phi'+\beta)\right), \quad (1)$$

where a is the Earth's centrifugal acceleration, $\beta\cong\beta_1\cong\beta_2$ is the angle that a plumb line makes (for mass 1,2) with the vertical, and $2l_1$ is the length of the torsion bar. The hypercharge fields due to the Earth and the building are denoted by y and y', respectively, with $y=\xi(\rho_{\text{local}}/\rho_\oplus)(B_\oplus/M_\oplus)\epsilon(R/\lambda)g$, $y'\cong\xi g'$ (where $\xi\equiv f^2/G_\infty m_H^2$, and g and g' are respectively the magnitudes of the gravitational accelerations towards the Earth and the building), and all other notation is as in Refs. 3 and 4. For typical institutional buildings[4] $M\cong(2\text{–}5)\times10^6$ kg, $M'\cong(8\text{–}20)\times10^6$ kg, and from the known dimensions of the basement above which the EPF experiment took place, $M'\cong14\times10^6$ kg, on the assumption of an average local mass density $\rho_{\text{local}}=2750\ \text{kg/m}^3$. The significance of the basement is that it acts as a "hole" in the otherwise uniform matter distribution of the Earth, whose effects are described by the first term in Eq. (1). Thus its effects could contribute with a sign *opposite* to that of the Earth as a whole, and can be substantially larger. If the picture of the matter distribution given in Ref. 4 were correct, then the actual EPF data would indeed correspond to a *repulsive* force.

The simple picture described above should not be taken too literally, since there were in fact other (perhaps more important) sources of local matter inhomogeneities. However, the preceding discussion makes it clear that local mass anomalies can be important because the magnitude of the horizontal hypercharge force component may be enhaced by as much as a factor of $1/\sin\beta$ with respect to that originally modeled in Ref. 1. Moreover, the sign of the horizontal component can be either positive or negative depending on the location of the anomalies relative to the apparatus. These arguments make it clear that the only unambiguous consequence of the intermediate-range coupling to baryon number or hypercharge is the *pattern* of points along a line plotting $\Delta\kappa$ vs $\Delta(B/\mu)$, and not the sign or magnitude of the corresponding slope.

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